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A Comparative Study of Transit-Oriented Developments in Hong Kong

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1. Abstract

Due to geographical and political constraints, the city of Hong Kong has developed into a dense metropolis. In the face of limited areas for expansion, the rail transportation system has grown to become the lifeblood of the city. In this paper, we look at the residential and commercial areas that have been built around prominent Hong Kong rail stations. Transit-Oriented Developments (TODs) are the walkable areas around MTR stations. They come in a variety of shapes and sizes, but their sustainability and ability to properly serve the needs of residents based on social, environmental and economic aspects has not been properly assessed. In this paper we devise more comprehensive tools to assess TOD sustainability. From this we provide a series of recommendations for new developments, as well as recommendations for improving the sustainability of existing developments both within Hong Kong and abroad.

We have expanded the current frontier of TOD sustainability research by developing a study focused on the interaction of social, environmental, and economic aspects. By focusing on the sustainability of developments from the perspective of residents, we present a methodology that can be applied to studying TODs throughout the world. The combination of quantitative and qualitative data collection provides for a robust and meaningful comparison between TODs. From this comparison we have identified walkability, integration of green areas into the built environment, and composition of aesthetically pleasing mixed-use buildings to be of chief importance. This includes both new developments and improving the existing developments we have studied.

2. Executive Summary

The city of Hong Kong's development is unparalleled to anywhere else in the world and its population continues to grow. Mass transportation systems are the lifeblood of the city. Although Hong Kong has geographical constraints that set natural limits on the spatial expansion of the city, and a plethora of national parks which prevent construction within their state-defined borders, the city continues to grow. Effective public transportation has taken root in order to serve the increasing population.

The Mass Transit Rail Corporation is the key player in Hong Kong. It has positioned itself as the largest provider of light-rail, tramway, and metro transportation in Hong Kong. Although originally a public entity, the MTR went private in 2000. Cooperation between city planners and the MTR is essential if new developments are to serve the residents of Hong Kong well. (Corporate Profile 2012)

Our study places the TOD residents as the primary impacted group. These are, in essence, individual communities fully serviced by the public transportation of the MTR. When evaluating the sustainability of these developments, it is their impact on local residents with which we are primarily interested in. TODs are profitable for the MTR, and those that own surrounding infrastructure; however, it is less clear how a TOD shapes the quality of life for residents.

To determine the sustainability of TODs, we have structured our study around the social, environmental, and economic aspects of sustainability. This is a pioneering study in that it focusing on collecting quantitative and qualitative data to assess the three aspects of sustainability. By using these data to form a meaningful comparison, a set of recommendations have been made to improve the quality of life for residents of existing TODs. In addition, we have developed recommendations for new TOD planning. These recommendations are flexible to be applicable not only in Hong Kong, but abroad as well.

3. Introduction

Due to geographical and political constraints, the city of Hong Kong has developed into a dense metropolis. In order to provide for residents, the public transportation system has been growing parallel to the development of the city. The public rail system of Hong Kong is one of the most diverse and efficient rail systems in the world. Any visitor to Hong Kong instantly recognizes that public transport is the lifeblood of the city. Hong Kong boasts a rich offering of public transport services including a high capacity railway, surface-street trams, an assortment of buses and minibuses, and ferries (Cervero, 2009). As it continues to expand to better serve consumers, Hong Kong rail companies have begun to look at integrating public transportation with residential living (Cervero, 2009). By integrating residential needs with attractive public transportation options, a rail Transit-Oriented Development (TOD) has the potential to offer a better alternative to private transportation in urban areas, and significantly improve the quality of life for residents.

Throughout this report, the concept of TOD will be defined and developed according to our expanded methodology, but we will begin with a provisionary definition that a TOD is a walkable environment, located around a rail transit station that hopes to provide a healthy lifestyle for its residents. However, the sustainability of TOD has not been fully studied, and only a few pioneering studies exist. In order to specifically assess their effects on Hong Kong residents, the current research has to be expanded. By studying the current definitions and standards, we have identified gaps in TOD research to expand on.

We have decided to study TODs in greater detail with sponsorship from The Hong Kong Institute of Education (HKIEd). Research shows the profitability of these developments, but no studies exist that evaluate the effects of TODs on residents. As the city continues to expand, Hong Kong will undoubtedly seek to maintain the high standards of rail travel it currently

enjoys. The governing principles of TODs offer a promising solution to Hong Kong's increasing sprawl in theory; however, only by thoroughly investigating current TODs can the sustainable effects on the residents be evaluated and understood. We have performed a comprehensive analysis focused around providing meaningful recommendations for new and existing TODs. Our conclusions are focused upon providing recommendations relevant to Hong Kong residents as well as TOD residents abroad. This topic has not been fully developed in the current literature, and we provide a research methodology elastic enough to be relevant for all TODs around the world.

3.1 Research Question

The current state of TOD research lacks breadth in qualitative and quantitative data. In order to robustly define sustainability, multiple indicators must be considered and evaluated. Our primary research objective is to provide a comprehensive methodology in order to assess the sustainability of five different types of TODs by comparison. These five TODs will be assessed according to the three major aspects of sustainability: social, economic, and environmental. No study currently exists that studies these three aspects by combining qualitative and quantitative analysis.

A sustainable TOD is a TOD that has minimal reliance on other areas in order to properly support its residents. These residents have access to all of their needs in the walkable area around their closest station, or within the walkable area around another station. In addition, a sustainable community minimizes waste to improve the quality of life for residents. We provide a comprehensive system of methods to evaluate the sustainability at each of the five existing TODs, and then draw conclusions relevant to the MTR corporation and government urban

planning departments. These conclusions are structured to improve the quality of life for current TOD residents as well as residents for future developments.

3.2 Discussion of Impacted Parties

The existence of a rail system is to serve residents and make their quality of life better, while the rail companies and the government are the builders of the rail system. Thus, these three groups are inter-related; the three facilitate the development of rail system, and are all affected in turn.

The first group impacted by the rail is Hong Kong's residents. They are the primary users of the current rail system. If the number of new towns and communities continue to grow, issues with the sustainability of TODs will arise at the same time. For example, with an increasing population, stations and trains will become excessively crowded, especially during peak hours. Also, if new communities in certain TODs become disconnected, whole groups of residents could become isolated because of the lack of access to the current rail system, therefore possibly cutting themselves from resources they might require.

In addition to TOD residents, the rail companies may be affected by our study. The largest rail company in Hong Kong, the Mass Transit Rail (MTR) Corporation has especially vested interests in the overall rail system and its developments. Since the MTR owns most of Hong Kong's rail system, it will be counted on to lead improvements to the rail system so that they operate optimally. If sometime in Hong Kong's future, the state of the rail system becomes compromised, and planning becomes inefficient, MTR will be expected to make the necessary changes to improve the rail system. In this situation another transportation company might step up and make the necessary changes, thus cutting into MTR's markets.

The Hong Kong Government has had a huge investment in Hong Kong's rail system. While it does not directly control the rail company's actions, if a new rail system were to be added to the city, the rail companies and the government would have to work together to find the most efficient way to add to the infrastructure of an already compact city. Moreover, the government is responsible for overseeing the safety of mass transit rail in Hong Kong. In addition it promotes a satisfactory quality of life.

By making the MTR, government, and citizens aware of the sustainability concerns of existing and new TODs, the above parties can begin improving these developments. For instance, if there is a rise in population, and the rail system does not increase the number of exits, more street congestion will result. The excess car and bus use will also add more pollutants to the air. This will create a greater health risk for the city residents. Although our primary impacted group is the residents, many of the urban planning decisions lie with the Hong Kong government.

3.3 Summary

In this paper, we will introduce the concept and classification of TODs to give a clear understanding about the development of the Hong Kong rail system. During our research we picked five stations: Central, Chai Wan, Olympic, Po Lam, and Wan Chai, representing different types of TODs. We studied their characteristics and measured their sustainability in order to give out recommendations to improve current TODs in Hong Kong. In addition, a more in-depth background on the definition of sustainability and methods of its assessment has been offered. We conducted structured observations and surveys to collect data, which can reflect the state of the rail system in social, economic and environmental terms. From this foundation, we

determined how sustainable the various TODs are and we made policy recommendations for the new communities.

We understand the state of the rail system is significant for the residents of Hong Kong, and their daily lives are influenced by the system deeply. Residents rely on public transportation so much that any flaws may cause serious problems in the current period or in the future. The rail system is not only the backbone of the city's structure, but also a sense of pride for the city's residents because of the effectiveness and developments of the system. By providing recommendations to new TODs, we can improve residential living around rail transportation stations. In addition to impacting Hong Kong residents, our recommendations encompass TODs abroad as well. Lessons learned from Hong Kong's developments are applicable internationally.

4. Background

4.1 Introduction

The Census and Statistics Department states that nearly 68% of workers in Hong Kong took either the MTR or buses to employment (Cho-Yam, 2010). Compared to any other transportation, the rail transit system provides a quicker, more comfortable service for passengers. Above all else, the rail makes transportation affordable for many low-income workers in Hong Kong (Cho-Yam, 2010). The growth of Hong Kong's rail system is due, in part, to its unique geographical and political history.

The geographical size of Hong Kong belies its tremendous population. Urbanized areas boast an average density of 26,473 people per square mile (Cervero, 2009). Hong Kong's population is split among these heavily populated areas. As a Specialized Administrative Region of China, Hong Kong enjoys a market-based economy that differs from socialist economy of Mainland China. The history of the rail system includes different stages of government regulation and control. Through these periods, rail transportation has grown to become the dominant form of public transportation in Hong Kong. The transportation system between the areas of downtown and the suburbs is a major asset to the economy and community.

Hong Kong is an international city with a total area of only 1,100km^2 and about 40% of the territory is covered by country parks, where urban development is forbidden (Loo, 2007). Despite this limited area, the population of Hong Kong has grown rapidly to more than 7 million people (CIA). The city continues to grow at a rate of 0.421% (CIA). The need for efficient transportation will continue to grow as new communities are developed. The HKIEd states in its report that "rail transit is a sustainable transport mode for the people of Hong Kong." (HKIEd, 2010). Above all else, the rail makes transportation affordable for many low-income workers in

Hong Kong (Cho-Yam, 2010). From this, Transit-Oriented Development has been shown to be a feasible solution to transportation in new communities.

Because of its density, Hong Kong faces the increasing need for sustainable forms of development to benefit its people. A resident's quality of life is influenced substantially by the means of transportation he or she uses (Wadhwa, 2000). The people of Hong Kong have moved to homes closer to the rail stations provided by the MTR. It has been to the resident's advantage to live closer to these stations, because it is effortless and trouble-free to travel throughout the city. As a result of this advantage, the government allowed MTR to build housing above stations, and the prices to own some of these homes are at the level that low-income workers can afford (Cho-Yam, 2010). In addition, to avoid the effect of congestion in heavily populated urban areas, more high quality rail transit routes are constructed, linking these rail-based developments.

4.2 History of the MTR

MTR is one of the most important rail corporations in Hong Kong and the world. The corporation started as a public transportation system owned by the Hong Kong government, and has transformed into an international private enterprise that controls nearly all of Hong Kong's rail infrastructure. MTR became privately owned in June of 2000 when the Hong Kong government sold 23% of the company into private hands, thus turning it into a private corporation. On December 2, 2007, MTR merged with competitor Kowloon-Canton Railway (KCR) Corporation (Corporate Profile 2012). While KCR was against the merger, KCR was also owned by the government, and was thus forced to merge. Afterward, MTR's name officially changed to Mass Transit Rail Corporation Limited, but it is still commonly referred to as MTR. After the merger, MTR had control of 168 km of directional rail along with 85 stations, averaging the distance between stations to less than 2 km per station (Cervero, 2009).

The MTR has a strong impact on the community. Millions of people use the rail every day, and if the MTR changes any of its policies, whole communities will be affected. If the fare of their trains changes significantly, then it can change the economic structure of the city due to restricted job opportunities for the poor in Hong Kong. As the government still owns a portion of the corporate stock, between 1984 and 2004 it has limited any increase of its fare to only 100% increases per 10 years (Tang, 2010).

4.3 Definition of TOD

The rail transit systems seek to further integrate public transportation into the larger urban areas as new towns are developed. This evolved into the concept of a TOD, which is the walkable area around the MTR station. Gordon summarizes many general attributes that define TODs. Low-density areas make the capital investment of rail transportation unattractive and wasteful (Gordon 2007). As an example, due to the growth of suburbanization and spreading of cities in the United States, public transportation has declined. Gordon goes on the state that despite 25 years of federal assistance, mass transit carries only about 5 percent of people who commute to work in the USA. Hong Kong, which carries 68% of its workforce to places of work, is remarkably different.

The difference is partially due its expansive urbanization and geographical constraints. The MTR has grown into one of the most sophisticated mass transit systems in the world due in part to these favorable conditions. Neighborhoods and communities are often located easily within walking distance of a public transportation station. By defining what radius around the station is walkable, a small community centered at the station can be constructed. Gordon states that the composition of individual buildings around the station is important in defining the

development as a whole. More detailed analysis of the composition and classification of different developments will be covered in the proceeding sections.

A Transit-Oriented Development is as a community of defined size focused around a rail transit station. The size and composition of the area around the station is not standardized and differs for each location. Gordon describes TODs by land area, while Cervero describes TODs by distance that an average person is able to walk from the station (Cervero 2009). For this project to be the 10 minute walkable distance from the station.

4.4 Connection between TOD and Ridership

One type of TOD includes high-density residential areas containing employment and shopping within short distances of a transit station (Lund, 2006). Another type includes the vertically focused stations with housing above. In 2006, Lund performed a survey of TOD residents in California. The results of this survey showed that residents who cite access to transit are 13 to 40 times more likely to use transit than those who do not. Lund goes further to show that TOD residents use rail-based transit at a higher rate compared to the overall population. These results are far from surprising, but give some evidence that TODs result in increased transit usage. Although this survey only considered sections of California, Lund (2006) states that the results are applicable to most TODs. She went on to conclude that those who had moved to TODs within the previous 5 years were not unlike the general population of the area, though they had higher household incomes (Lund, 2006). The demographics of TODs are a useful metric for evaluating which sections of the general population are being directly benefited by TOD design and ties into the sustainability of the area.

There have been studies published assessing the effect of Transit-Oriented Developments specifically in Hong Kong. As the MTR continues to expand with the addition of more TOD-

focused projects, Loo (2010) states that an MTR station with a transit-oriented design adds around 35,000 weekday passengers. This study tried to determine whether stations located in TODs had more ridership than similar stations outside of TODs. Loo found that "The biggest ridership bonus comes from transit-oriented developments tied to large-scale residential projects" (Loo 2010). The residential aspects of the TOD determines their success from a financial standpoint. Without constructing these zones to be attractive to the permanent residents, they cannot grow and succeed. Loo firmly established the connection that TODs have a large impact on rail usage, a claim that was backed up by Lund as well.

4.5 Classifications of TODs

One of the most prolific TOD researchers who tracked various developments specifically in Hong Kong is Robert Cervero. In his 2009 paper of *Rail and Property Development in Hong Kong*, Cervero and Murakami performed a cluster analysis of 25 MTR stations designed specifically from a rail design standpoint and categorized the TODs into five major archetypes (Cervero 2009). These five were High-rise office (HO) which contained mostly offices in a small area, High-rise residential (HR) which contained residential buildings in a small area, Mid-rise residential (MR) which contained medium-density housing projects, Large-scale residential (LR) which contained much less dense residential areas over a larger area, and finally Large-mixed use (LM) which contains a mix of housing, offices, retail, etc. over a larger area (Cervero 2009). Cervero went on to list the specific stations that fell under each category, and more details on the variables used in the cluster analysis.

This analysis was performed by constructing a series of linear models that accounted for gross floor area by use (office, residential, hotel, retail). In addition, a mixing index was introduced to categorize how varied the area around each station was. Cervero only included

stations where the area surrounding the station contained a mixture of different uses. The density of the area around each station was computed by a ratio of building area to land area (Cervero, 2009). The area around each major rail station in Hong Kong was analyzed according to these variables. From this, five clusters of similar attributes were identified in the twenty-five stations that met the minimum walkability and mixing index (Cervero, 2009).

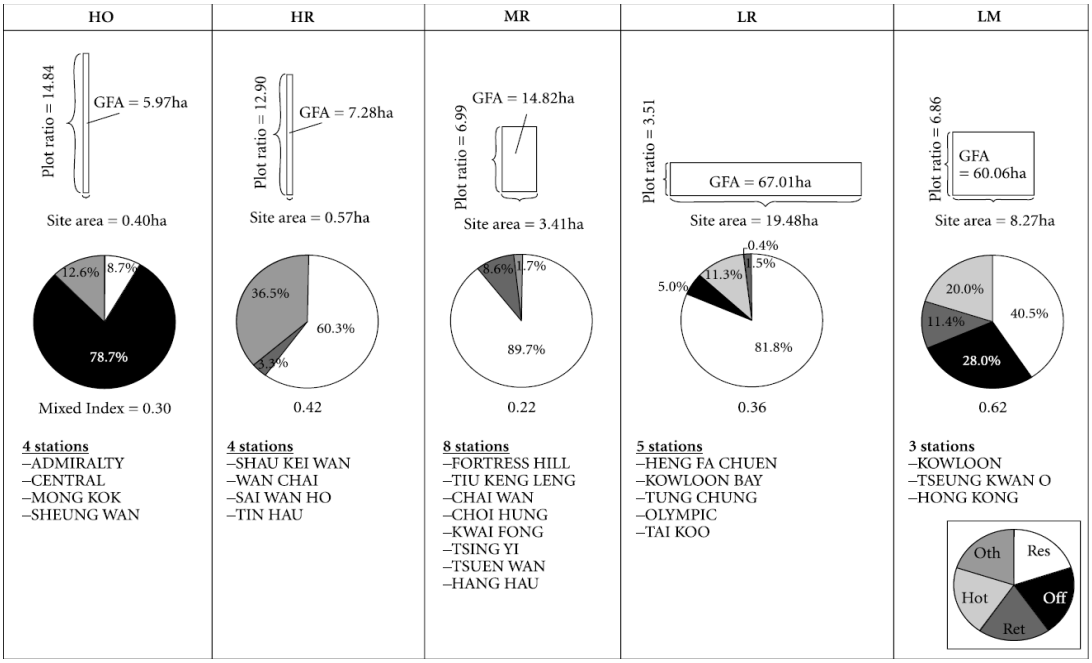

Table 4.1.0
This chart shows the five different category types of TODs as defined by Robert Cervero. (Cervero 2009)

Table 4.1.0 summarizes some of Cervero's relevant findings by providing different classifications for different Hong Kong TODs. These five classes are High-rise Office (HO), High-rise Residential (HR), Medium-sized Residential (MR), Large-size Residential (LR), and Large-size Mixed-use (LM).

4.6 Introduction to Sustainability

4.6.1 The Three Aspects of Sustainability

The quality of residential projects strongly affects the financial growth of TODs, but often the effect of the TOD on its inhabitants is more subjective. The sustainability of these developments has been identified by John Renne as an aspect to be further evaluated. Renne considered five different Transit-Oriented Developments in Western Australia. His study focused on defining sustainability, and he evaluated each TOD according to criteria he developed. Renne begins by defining sustainable development as managing urban growth, integrating land use with transportation and produce compact, mixed-use, precincts around transport stations (Renne, 2009). He concludes that "sustainable development seeks to create an urban environment which maximizes economic development and social equity, whilst minimizing negative externalities upon the natural environment" (Renne, 2009). Therefore, a sustainable TOD must be a convergence of three broad topics. These are economic development, social equity, and environmental stewardship (Renne, 2009). From these three overarching principles, six aspects of outcomes are developed. These are Travel Behavior, The Local Economy, The Natural Environment, The Built Environment, The Social Environment, and the Policy context (Renne, 2009).

Renne's study was conducted on five different TODs in Western Australia. Instead of performing a matched-pairs analysis, it was decided to use a comparative study of the five TODs. The major problem with a matched-pair analysis is that it is nearly impossible to find two similar developments that exhibit similar characteristics (Renne, 2009). Instead, by performing a study across multiple TODs, a comparison of their relative sustainability will produce a more valid result.

In 2005 Renne performed a study of TODs in New Jersey. This study surveyed residents on what indicators they themselves found important in qualifying their TOD (Renne and Wells, 2005). The major indicators identified were qualitative rating of streetscape, pedestrian activity, number of transit boardings, population/housing density, and estimated increase in property value (Renne and Wells, 2005). Fifty six total indicators were thus defined, and Renne and Wells identified the following nine as the most essential for evaluating TOD sustainability. These include transit ridership, population and housing density, quality of streetscape, quantity of mixed-use structures, pedestrian activity, property values, public perception, transit connections, and parking configurations (Renne and Wells, 2005).

In addition to Renne and Well's nine essential indicators, there has been additional research done which looks more closely at different topics in sustainability. The quality of residential projects strongly affects the financial growth of TODs, but doesn't fully consider rider satisfaction. Lam, Cheung, and Lam, conducted a detailed analysis of Hong Kong Light Rail riders (Lam, 1999). From an interview survey on rail transit users, a model of crowding response was constructed. Evaluating this model allowed Lam to distinguish what factors had the strongest effects on rail user happiness. He concluded that with the same on-platform waiting time, the passengers' responses to congestion at different stations are similar. In addition, Lam found that passengers respond differently to the crowding conditions depending on different journey times. From this study, one can conclude that structuring stations to minimize crowding and exploiting the potential for shortening distances between stops has a marked effect on rail user happiness.

4.6.1 Connection between Air Quality and Sustainability

Generally, the development of a city's transportation system will influence the environmental aspects of its residents. There are two big environmental problems relevant to the

growth of the rail transit system. These are the indoor air quality of the vehicles, and the noise levels in the surrounding areas. These issues directly affect the environmental sustainability of the TODs for community residents.

In 2003, recommended standards for the indoor air quality (IAQ) of public transportation were established in Hong Kong. According to these standards, the air quality in the passenger cabins of railway vehicles may be improved through the ventilation system using outside air. Also, it is reasonable to use the carbon dioxide (CO_2) level as the index of improvement (Kwon, 2008). The IAQ of MTR in Hong Kong is a significant factor to estimate the achievements and limitations of the public transportation, and its effect on riders. Negative environmental effects on riders can cause health issues and discourage ridership.

The air quality beyond the limits of the MTR station has a large role in the environmental sustainability of each TOD. A paper by Borrego showed through air quality simulations that urban structures have a large effect on the air quality within the city (Borrego, 2006). Through a mixed fluid-dynamic and chemical diffusion model, each different type of city was exposed to similar conditions. The cities that contained compact mixed-use buildings, airflow corridors, and centralized design were able to distribute pollutants more efficiently. This also prevented entrapment of these chemicals. These results were proven through computer simulation, and Borrego was able to show a theoretical link between the air quality within each area, and the design of the area.

4.6.3 Connection between Noise Pollution and Sustainability

Public transportation is convenient for the residents; however, it also creates noise. Excess noise affects people's health and mood in a subtle way, and decreases the quality of life for residents. Researchers conducted a study to understand residents' feelings about mixed

transportation noise in Hong Kong. The results of this study show that annoyance is largely caused by noise disturbance and perceived noisiness (Lam, 2009). When road traffic noise dominates, annoyance is primarily determined by noise disturbance caused by the peaks of railway noise events. When railway noise dominates, peaks of train events can induce a direct annoyance response (Lam, 2009). Noise is a criterion to assess the quality of living in TODs. By reducing the noise made by commuter rail, the mental states of residents will improve.

4.7 Summary

Sustainability is inherently a subjective quality that can be approached in many directions. After foundational studies in transportation sustainability; specific social, environmental, and economic aspects must be considered in turn. A comparative study provides the best framework to compare different types of TODs in Hong Kong. These types have been described by Robert Cervero. Environmental sustainability encompasses the green area of each TOD as well quantitatively measurable parameters such as air quality and noise pollution. Social sustainability includes the walkability of the built environment, and the resident perception of their environment. Economic sustainability includes the expected housing prices within the area. A meaningful study will evaluate all of the sustainability indicators, and well as combine and compare the individual data sets.

In order to assess the limitations of TOD sustainability for residents, a solid framework has been developed. This framework is based primarily on Robert Cervero's definition of TODs and John Renne's definition of TOD sustainability. While these papers provide a starting point, we have improved on their measurements of sustainability by providing a comprehensive research methodology. This methodology is focused on assessing the sustainability of TODs with respect to resident quality of life.

5. Methodology

5.1 Introduction

The goal of this research begins with assessing the sustainability of existing TODs in Hong Kong. From which we will provide recommendations for the planning of new developments, and improvement of existing developments. Our research methodology was devised to look at the social, economic, and environmental aspects of a TOD. This allows for a robust comparison of sustainability. For this research, we looked at five different TODs selected based on the five types of TODs defined by Cervero in 2009. These TODs were chosen such that no TODs were adjacent. They cover Hong Kong Island, Kowloon, and The New Territories. The five TODs we evaluated were Central, Wan Chai, Chai Wan, Olympic, and Po Lam for the categories high-rise offices, high-rise residential, medium residential, lower residential and large mix respectively. While Po Lam is not mentioned in Cervero's paper as a Large Mix TOD, being in the same area as Tseung Kwan O, it has all of the characteristics of a mixed TOD. A map of these locations is found in Figure 5.1.0.

Figure 5.1.0
Map of Study Areas

In order to evaluate the sustainability of a TOD, we employed structured observations, measurements, and surveys. These methods are summarized in Figure 5.2.0. The data collected from observations and measurements provided a starting point for evaluating sustainability, providing both quantitative and qualitative data of the area. Taking notes and photographs of the area has allowed the researchers to assess each TOD's sustainability. Data collected from surveys completed by TOD residents provided information about the opinions of residents and workers in each TOD. The survey data provided an internal check to ensure that the observations we made were relevant to Hong Kong residents. Through these structured observations and surveys, we were able to examine the social, environmental, and economic aspects of each TOD and thus evaluate their sustainability.

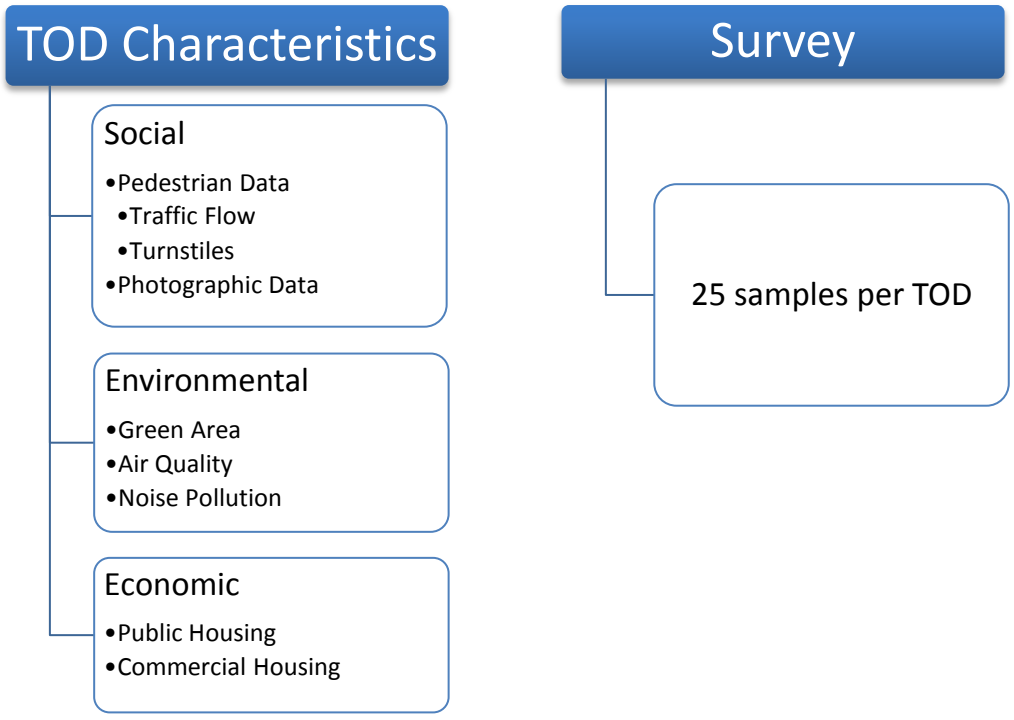

Figure 5.2.0
Summary of Methods

5.2 Defining each TOD

Robert Cervero classified each TOD in Hong Kong as the walkable area around an MTR station which included mixed-use sustainable buildings (Cervero 2009). Cervero drew the boundaries of each TOD around residential housing data available at the time. Our choice to modify this definition was brought about by a greater interest to study the area typically traversed by residents. It was thus decided to look at a 10 minute walkable range from the MTR station. This provided a manageable and relevant area for study. This 10 minute range was different for each TOD, and the following provides a method by which this range was defined.

The MTR Corporation provides maps of the area around each station. These maps include all local attractions and major buildings; however, these maps often exceeded a defined walkable area. In this paper, walkable area is defined as a 10 minute walking distance. To determine this distance, we started at four ordinal directions and walked at a constant pace. At five and ten minutes, each researcher noted their locations. From these walking distance data, we found the limits of each TOD for use in our analysis.

5.3 Evaluating the Social Aspects of Sustainability

Evaluating the social sustainability of each TOD fell into three broad categories. MTR station data was collected at train turnstiles and exits. Street data was taken at walkable areas in each TOD. Mixed use and sustainable buildings in each TOD were also categorized. Pedestrian traffic flow both at the station and on the street were the primary focus for observations. Measurements of how congestion is distributed both within the station and in the surrounding TOD was a major indicator for Renne's research. Mixed use and sustainable buildings is the other primary factor in social sustainability. The built environment around each TOD must provide a variety of services to residents within walking distance. Social factors study the

integration of the MTR station with the surrounding area.

5.3.1 Pedestrian Flow and Walkability

All measurements started with evaluating pedestrian flows through the station turnstiles. Turnstiles represent a natural bottleneck since each person has to process tickets. It is the most convenient method for measuring the amount of persons entering and exiting the TOD through rail. Cervero's paper shows that rail is the primary means by which residents travel to other TODs in Hong Kong (Cervero 2009). Turnstile counts were done for both inflow and outflow at each of the five TODs. At least two researchers counted simultaneously and an average was taken for any discrepancy. Large deviations in counts were discounted altogether. All pedestrians were included except for young children who were unable to walk. Many of the stations had multiple turnstile blocks, and these were summed together.

Pedestrians were counted over a five-minute period in order to ensure that one train for each connecting line would be counted in the outflow. These five-minute counts were performed between Monday and Friday, between 11:45 and 13:00 for all TODs. Researchers were allowed to use their own personal methods for counting and record keeping; these included notebook, phone application, or by memory. Once the count was completed, a final tabulation was recorded for each researcher and the inflow/outflow data were separated.

While turnstiles were used to evaluate the principle method by which people enter and leave the TOD, station exit counts served to measure how the dispersion of residents and visitors occurs and how they traverse the TOD. All stations contain multiple exits which are placed to connect MTR passengers to the local environment. The congestion of these exits directly correlates with usage of the exit. Some exits lead specifically to street level, and others lead to a Sino Group owned mall. Exit counts were conducted in 5 minute durations. Researchers were divided into two groups, one group was in charge of inflow, while another group counted

outflow. These measurements were performed between 11:45 and 12:15 on workdays. Stations were mapped according to their highest inflow/outflow rates, and then compared.

5.3.2 Photographic Analysis

In order to capture a better image and understanding of all the areas that have been studied and observed, picture images were taken for use for comparison. We walked around each TOD and became tourists for a day, doing sightseeing and searching for areas that caught our eyes. We strove to look for every structure or edifice that seemed to be sustainable for a community. Once these areas were identified, they would be photographed. But in order to retain the visual image of each TOD, we used a digital single-lens reflex camera, Nikon brand, model type D3100 with Nikon 18-55mm zoom lens, to capture each 14-megapixel image in a .jpeg format.

A great amount of pictures were taken around the areas, but to organize a mix of random pictures, a checklist needed to be made. We decided on taking pictures of the MTR station entrances, both the inner walkway and the outside layer of the bridges, all of the major green areas, the different types of buildings surrounding the station, specifically the office buildings, malls, and especially the residential areas, and finally all the transportation locations such as taxi stands and bus terminals. As a group we gathered the multiple images and distributed them into specific categories so they can be compared and used as references for our results.

5.4 Evaluating the Environmental Aspects of Sustainability

Evaluating the environmental sustainability of each TOD required three different approaches. Satellite mapping was used to discern what fraction of each TOD is comprised of green areas. Noise pollution measurements were performed in the MTR station surroundings to

find how good the TODs were at dissipating excess noise from the stations and surroundings. Air quality measurements were taken for CO_2 levels around each TOD.

5.4.1 Green Areas

Satellite mapping has proved to be most useful for determining the green areas in each TOD. Over the 21st century SM has evolved into an effective and affordable method for observing large-scale phenomena capable of being separated by color (Mathieu 2007). Satellite mapping has been used for research from mapping landslides (Mondini 2011) to mapping the spaces of private gardens in urban areas (Mathieu 2007). The majority of these papers follow a similar methodology. First, the satellite software is used to produce an image file. Then other software programs are used to separate the pixels of interest from the bulk of the file (Mondini 2011).

In our project, open source software was used to provide flexibility. We used Google inc. satellite imaging service Google Earth (Access Intelligence 2006). The Linux open-source photo editor GNU Image Manipulation Program (GIMP) was used to process the satellite images. first we used Google Earth to display each of the Hong Kong TODs. Then an image file was exported from the program and into GIMP. Using GIMP, the green parks and sports fields were identified and their pixel size was recorded. The green fraction of each TOD was determined as the fraction of total green areas to the total TOD land area. The result is a scaled metric suitable for comparison. Instead of using filtering software to count the total number of green pixels, the method of manually measuring the pixel size of each park was adopted. The parks and sports fields were our primary interest.

5.4.2 Air Quality

The equipment to measure air quality was loaned by the Department of Science and Environmental Studies of HKIEd. Outdoor air quality studies have been accomplished to varying

degrees of detail depending on budgeting and equipment availability. A preliminary study of air quality in primary schools in Lisbon by Pegas presented a simpler methodology requiring less sophisticated equipment, but still producing significant results (Pegas 2010). In our study, measurements were taken at each outside MTR station exit 5m from each TOD station. It was important to take all measurements within the same day, and at as many locations as possible. Day to day fluctuations and hourly fluctuations in CO_2 levels were minimized by performing all experiments efficiently in a two hour timeframe. The instrument was fitted with fresh batteries and operated according to all instructions. CO_2 levels were recorded at all locations. Individual recordings were taken in a one minute window. Within that window the minimum and maximum CO_2 level was recorded. These values were averaged to compare with other TODs

A Metrosonics aq-5000 Air Quality Monitor was used for all measurements. Carbon Dioxide was measured using the non-dispersive infrared detector (NDIR) at a range of 0 to 5000 parts per million (ppm) with an accuracy of ± 50ppm. Values were taken down after 90 seconds to take into account the equipment response time. Crosswind effects were minimized by taking measurements away from heavily windy areas and during lulls of airflow. All measurements were taken in open environments at a distance of 1.5m from the ground.

5.4.3 Noise Pollution

Noise equipment was also borrowed from the same department of HKIEd. Measurements were taken at the entrances of each of the stations during typical pedestrian flow. Taking measurements at each entrance serves to show specific problem areas of each station, as well as giving sufficient data for comparison among the other TODs. Data was collected at each exit in a one minute period with minimum and maximum values recorded. These values were averaged and compared across other TODs.

A Lutron SL-4001 Sound Level Meter was used for all measurements. Equipment was

properly calibrated and fitted with fresh batteries. Sound levels were taken at a standard 1.5m distance from the ground. A similar method was used by Anand, Wenham, and Bodenham in a study to measure noise levels in hospital Intensive Care Units (ICUs) (Anand, Weham, Bodenham 2009). All measurements were performed at a minimum of 5m from the entrance. Additional distance for measurements was intended to prevent any echo from the entrance region. Response time was set to the slow 500ms poling, this minimized any instantaneous noises, and helped measure the ambient sound. This allowed more blending of frequencies and easier to calculate average values. All values were recorded in decibels (dB).

5.5 Evaluating the Economic Aspects of Sustainability

Economic observations were grounded in studying housing prices within each TOD. Both public and the amount of commercial housing buildings were considered. For public housing, we received information from the government websites. We analyzed the data to find the availability and price distribution for Hong Kong residents. For commercial housing, looking into the overall price trends over five years.

5.5.1 Public Housing

According to the data from Hong Kong Housing Department and Hong Kong Housing Authority (HKHA), we found that there are more than 2,000,000 residents living in the public housing estates, owned by HKHA, Hong Kong Housing Society (HKHS), and Hong Kong Settlers Housing Corporation Limited. The distribution and availability of public housing estates in these TODs is a significant index to estimate the sustainability of these TODs.

The first step was to make a list of the names of public housing units located in the areas of five TODs. By using the station location map, provided by the MTR, we found nine public housing estates, one near Olympic Station, another close to Po Lam station, and seven of them in

Chai Wan. Next, based on the List of Public Housing Estates in Hong Kong, we made several tables to display the information, such as the number of residents and the location of buildings for each public housing estate. Comparing the resident data and the total population data in one TOD, we could figure out the availability of the public housing estates. We compared the number and locations of public housing estates with the commercial residential buildings. We figured out the differences in distribution of public housing units among five TODs. From we could also find out the characteristics of each TOD to judge whether it is sustainable for the residents or not.

5.5.2 Commercial Housing

Besides the public housing service, there were large amount of commercial residential buildings distributed in each TOD except Central, which contains mostly high-rise offices according to Cervero. Similarly to public housing, we focused on the station location map, and picked out 23 real estate buildings around the four stations. Centaline Property is one of the biggest and most encompassing real estate companies in Hong Kong. From its database, Centadata, we got the prices of these commercial estates from 2008 to 2012 in four TODs. We then worked out the average price per square foot per year for each estate. From the price trend, we could figure out the current pricing, and use the pricing trend to extrapolate future values. Noting the tendency of housing prices in the recent five years we could find the change in demand of the TOD. For example, the prices of apartments located in Olympic TOD tend to be higher year by year, it indicate a higher housing demand in that area.

5.6 Resident Survey Methodology

Surveys provided input from residents and those working within each TOD. Survey methodologies provide the foundation for many TOD studies, including Renne and Lund. Due to the time constraints of this project, it was not possible to perform a survey as in-depth as Renne.

In order to perform within these time constraints, it was necessary to be highly selective in survey construction and dissemination.

Survey planning began with choosing an acceptable sampling size. The goal was to be able to compare responses across five TODs. Fuller's statistical sampling text recommends a minimum value of 25 samples to provide enough data points for a properly analysis to be conducted (Fuller 2009). Thus a minimum value for a statistically significant sample was chosen to be 25 for each TOD, resulting in a total sample size of 125 spread across 5 areas. Maintaining a minimal sampling size ensured a high response rate that fit the time constraints of the project. With this sample size, statistically significant mean value testing can be applied (Fuller 2009).

Once the sample size was determined, the dissemination method could be decided upon. Instead of a lengthy mailing process, it was timelier to distribute surveys in the TOD areas directly. With this methodology in mind, the survey was designed to be as concise as possible. It included multiple-choice questions as well as open-ended questions. The full English language survey is included in the Appendix E. Questions were grouped in order to have residents and employees within each TOD share their thoughts on sustainability. The survey questions covered many of Renne's indicators including frequency of use, walking time to station, and traffic patterns (Renne 2009). Questions were written in order to prompt subjects to generate unbiased data that was impossible to collect through observation. The subject's views on noise, air quality, congestion, and environmental aesthetics were of chief importance. The transportation usage provided a means of verifying Lund and Renne's results. This suggested that those living and working within a sustainable TOD will strongly prefer rail transportation over all others and regularly use such transportation (Lund 2007).

Survey dissemination was performed in five of the TODs over the course of two days. The original survey was translated into Cantonese, and Cantonese-speaking students from the HKIEd were used to ensure all potential subjects could properly complete the surveys. English-

speaking students were in attendance as well, for the cases when subjects preferred to complete the survey in English. Each of the five TODs were surveyed by a team of three researchers, including two English-speaking WPI students and a minimum of one Cantonese-speaking HKIEd student. Groups traveled to public areas around each TOD, and subjects were chosen as those either living in, or working within the TOD being surveyed. As such, malls and tourist attractions were avoided, to exclude tourists and those from other parts of Hong Kong. In Central in particular, the majority of subjects were employed in the area, due to the nonexistence of residential buildings. No identifying information was taken from subjects. No further requirements were used in selecting subjects, and randomization was preserved by asking all potential subjects in English and Cantonese. Once the required number of 25 responses was met, the next area was investigated.

Surveys were analyzed in two stages. Population means were constructed for each question, and the sample mean of each TOD was compared to the corresponding population mean. This tested to see if the residents of each TOD were more likely to deviate significantly from the overall population. Free response questions were coded for common responses, and then the two most common for each individual TOD were recorded with their respective counts.

5.7 Summary

The research methodology used in this paper had the goal of being as robust as possible within the time frame. Instead of focusing on depth in one aspect of sustainability, greater breadth was allowed for a more meaningful comparison between the five TODs. Qualitative and quantitative observations were used in tandem to improve the criteria for comparison. Traffic flow patterns, green area calculations, housing prices, and air quality measurements provided for quantitative results which could be easily compared. Photographs and the total green area were

qualitative results which served to further develop the quantitative results. Surveys were critical in expanding and validating our observational results. The opinions of each one of TOD's residents allowed us to get a better idea of what the residents truly felt was missing in their environment. As an exploratory study, we chose to address these topics broadly. With an ultimate goal of further refining these techniques, and determining what aspects of sustainability needed to be re-defined. By collecting these data, the full comparison of the five TODs could be constructed and a series of recommendations could be constructed.

6. Results and Discussion

6.1 Introduction

Each TOD was studied separately over a period of four weeks. During this time all fieldwork was accomplished according to the methodology previously described. To begin, unstructured observations of the five areas were conducted. Sustainable buildings and photographs were for a preliminary assessment of each area. Traffic flow, turnstile counts, walkable area, and economic considerations were performed in the second stage around each area. Surveys were completed over a period of two days and comprised the third stage of fieldwork. Finally, air quality and noise pollution were taken over a small time-period in one day. Raw data was compiled and analyzed together after each stage of fieldwork. These data have been checked for regularity and no outlying or questionable values were observed.

6.2 TOD Walkable Areas

The following five maps show the walkable area for each TOD as determined by a series of four walks done by the researchers. Five maps were created for each TOD studied and shown in Figure 6.1.1-5. The red MTR symbol denotes the MTR station where the walks began. All four researchers started from this location. The black lines stemming from the MTR symbol are the paths we walked. Due to the geography of the city, it was impossible to walk directly in each ordinal direction. Instead, we tried not to deviate from their overall direction and follow the pedestrian walkways. The locations reached at 5 minutes were connected in a circle to provide a walkable zone, outlined in red. The locations at 10 minutes were also connected into a separate circle, also outlined in red.

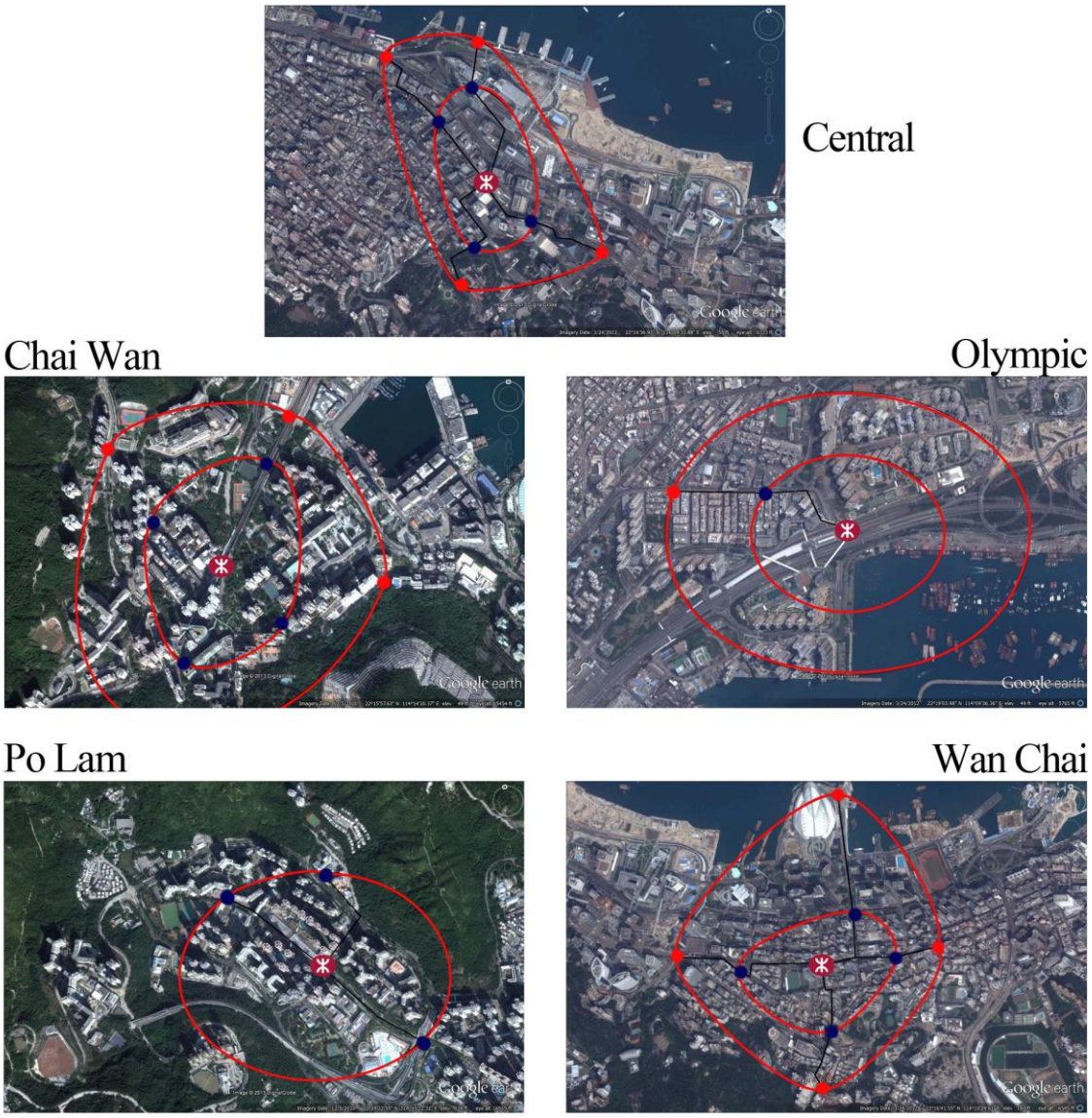

Figure: 6.1.1-5
Walkable area of each TOD, MTR logo is the MTR station, red lines with blue dots are 5 minute range. Red line with red dots is 10 minute range.

Olympic station was unique in that only one walkable path was considered. This is due to the fact that the majority of pedestrian traffic exits the HSBC building to enter Tai Kok Tsui Boulevard. These results will be supported in our traffic flow analysis in the next section. In the case of Olympic, two geometric circles were constructed from the 5 and 10 minute location reached.

6.3 Social Observations and Measured Data

6.3.1 Station Flow and Walkability

We based most of their pedestrian data off of the MTR station's exits. In the Olympic, Po Lam, and Wan Chai TODs, the exits were considered for pedestrian data due to the amount of people using the overhead walkways which diverged from the stations. Since Central and Wan Chai are both large underground stations, it was more difficult to efficiently and accurately measure the amount of pedestrians at each exit of the station. However, in the case of Wan Chai, there is a main bridge which serves as an artery for the area which connects to the northern government building, so we decided to measure its pedestrian flow. In addition, the bridge over Connaught Road which connects the Central and Hong Kong Stations was also measured. This is the only efficient way for pedestrians to travel across Connaught Road without using the underground passage that connects the two stations.

Pedestrian Data			
Station	**Bridge**	**IN (People)**	**OUT (People)**
Central	Connaught Bridge	242	278
Chai Wan	Exit A	111	96
	Exit B	99	73
	Exit C	59	36
	Exit D	45	25
	Exit E	79	66
Olympic	Exit A	67	34
	Exit B	45	47
	Exit C	40	43
	Exit D	177	173
	Exit E	57	65
	Tai Kok Tsui Rd.	Total: 490	
Po Lam	Exit A1	106	138
	Exit B2	94	136
	Exit B3	33	19
Wan Chai	Government Bridge	601	630
	5 Gloucester Rd.	Total: 26	

Table 6.1.0
Average number of pedestrians entering and leaving MTR station exits

In the turnstile data, Central and Wan Chai had the greatest amount of pedestrians entering and leaving the stations. For Central in particular, one turnstile set was heavily favored and saw the largest net flow of all the stations studied. In the case of Wan Chai, there was not as severe of a disparity in turnstile use, the flow was more evenly distributed. Olympic, Chai Wan, and Po Lam had similar turnstile results. It can be seen in the table that for each station there is one primary turnstile set that sees the most traffic.

Turnstile Data						
		STATION				
	TURNSTILE	**Central**	**Chai Wan**	**Olympic**	**Po Lam**	**Wan Chai**
IN (People)	**1**	259	122	115	114	154
	2	188	67	70	84	97
	3	17	N/A	N/A	N/A	67
	Total	464	189	185	198	318
OUT (People)	**1**	251	99	78	34	174
	2	75	29	74	41	155
	3	94	N/A	N/A	N/A	47
	Total	420	128	152	75	367

Notes

Central:
Turnstile 1 – Exit C-side
Turnstile 2 – Across from exit F
Turnstile 3 – Island Line Level, near shoe repair man

Chai Wan:
Turnstile 1 – Exit A-side
Turnstile 2 – Exit D-side

Olympic:
Turnstile 1 – Near Olympic city 1
Turnstile 2 – Near Olympic city 2

Po Lam:
Turnstile 1 – Exit B-side
Turnstile 2 – Exit A-side

Wan Chai:
Turnstile 1 – The turnstile closest to exit A3
Turnstile 2 – The turnstile between the other two turnstiles
Turnstile 3 – The turnstile furthest from the exits

Table 6.2.0
Average number of pedestrians entering and leaving MTR station turnstile

In the case of station exits, there were often significant differences in the amount of pedestrian flow within the same station. Olympic station in particular had a large amount of

pedestrians preferring Exit D over the others. Chai Wan featured a more even distribution, but the difference between exit A and exit D shows the absolute range in fluxes is 66 pedestrians in, and 71 pedestrians out. In general, the ranges of pedestrian flows were large for all stations in which multiple exits were considered. The Government Bridge exit of the Wan Chai station exhibited an extremely heavy net pedestrian flow rate. Connaught Bridge in Central also exhibited similar congestion.

The sidewalk length data shows potential bottlenecks along major pedestrian thoroughfares in each TOD. In Central, we found large pedestrian flow rates, and sidewalk widths were typically also large to compensate, with the areas closest to the MTR station such as Chater Street and the AIA Central Bridge having widths close to 0.5m. The two exit bridges in Chai Wan had widths of 0.22m and 0.25m for their level of pedestrian traffic. The areas around Olympic Station had the most varied widths, with areas of Tai Kok Tsui road being extremely small with bottlenecks at Fuk Chak Street with the Olympian City thoroughfares being quite larger. This corresponded to enormous congestion upon exiting Olympic Station. Walkways and bridges within the station, as well as the Olympian City were much wider and were far less congested. The exit widths in Po Lam were more than sufficient at 0.32m and 0.25m.

Sidewalk Data		
Station	**Location**	**Meters**
Central	Charter Street, in front of Salvatore Ferragamo	0.43
	Connaught Road, Mandarin Oriental Hotel	0.27
	Intersection of Charter and Club street	0.43
	Bridge AIA Central	0.48
	Charter Garden facing Bank of China Tower	0.22
	Des Voeux Road – Bank of East Asia	0.19
	Walkway leading South	1.02
Chai Wan	Exit D bridge	0.22
	Exit E bridge	0.24
Olympic	MTR Exit D walkway	0.43
	Parallel to the Naturalizer Shoes	0.81
	In front of Bauhaus	0.37
	Joy & Peace	0.90
	OTO Pillars, Babies	0.36
	3rd floor, behind OC sign	0.42
	Corner of Tai Kok Tsui & Pok Man Street	0.20
	Fuk Chak St	0.16
	Bank of China Tai Kok Tsui Rd #7-11	0.55
	Cosmo at Tai Kok Tsui Rd	0.03
	Wang Yip Ind. Building, on Anchor St.	0.24
	Street in front of Kowloon Plaza	0.27
Po Lam	Metro City 3 street facing Metro City 1	0.32
	Exit B_2 bridge	0.35
	Exit B_3 walkway ramp going to the park	0.22
Wan Chai	Hennessy Road by McDonalds	0.22
	Government Bridge	0.34
	Lockhart Road near 151/7-11	0.32
	Central Plaza Sidewalk, Wan Chai Tower	0.33
	Performing Arts Bridge	0.26

Table 6.3.0
Measured length of TOD sidewalks

6.3.2 Photographic Analysis

From Cervero's paper we had preliminary expectations of how each TOD was mapped out. Each station had differences in size, structure and the environment around it. Whether it was specifying the walkability, the different residential areas, shopping centers, green areas, street

life and connections to different transportations; we were able to quickly observe the important sustainable buildings and areas each station had to offer.

To compare each of the TODs through photograph, we observed the way the area was assembled. Central and Wan Chai had a similar structure due to the high-rise classification in buildings. To go more in depth in detail, Wan Chai has many high-rise residential buildings in comparison to Central having many high-rise office buildings, but they share a common factor that most of their buildings were closely connected with barely any space between them. The street life and traffic were very crowded; pedestrians were forced to rely on the walkway bridges to pass through many of the streets at a faster pace.

Olympic, Po Lam, and Chai Wan were also closely related in structure. Their MTR Stations were built to be above ground, and the walkway bridges act as the primary choice for pedestrians leaving the station. At least one of its many bridges connected to a park and a sustainable shopping mall that provided easy access to the ground floor. Once one approached the ground floor, many other transportation options were available.

Each TOD had taxi stands and bus stops around the MTR stations, but Central and Wan Chai had two additional types of transportation: light rail and ferry transportation. A few common factors of the TODs were the presence of a health care center, a post office, and a fire station within five to ten minutes of the MTR station. An uncommon factor that we observed was that the only TOD that did not have a police station within ten minutes of the MTR station was Olympic. Our photographic data is found in Appendix B.

6.4 Environmental Observations and Measured Data

6.4.1 Green Area

The green area fractions for each TODs are shown in the pie charts below. By

representing the green area as a unitless fraction of the total area, data can be compared across the TODs. The five green areas can be loosely categorized into three groups. Central's fraction is the lowest at 9.32%, with most of the green areas comprising small sporadic parks and sports fields. Wan Chai and Olympic had similar green areas of 20.67% and 23.80%. These TODs had significant amounts of parks and recreational fields. Olympic in particular has rooftop parks to offset the urban density of Tai Kok Tsui. Chai Wan and Po Lam had the highest green area fractions with 30.23% and 34.5%. Both TODs featured extensive park area designed to be fully integrated into the urban planning of the TOD. Chai Wan Park could be directly accessed through Exit D from Chai Wan MTR station, and the Po Lam park walkway is accessed through Exit B3 of Po Lam station. In addition, both had recreational fields throughout the area. Figure 6.2.0 shows a pie chart of this data.

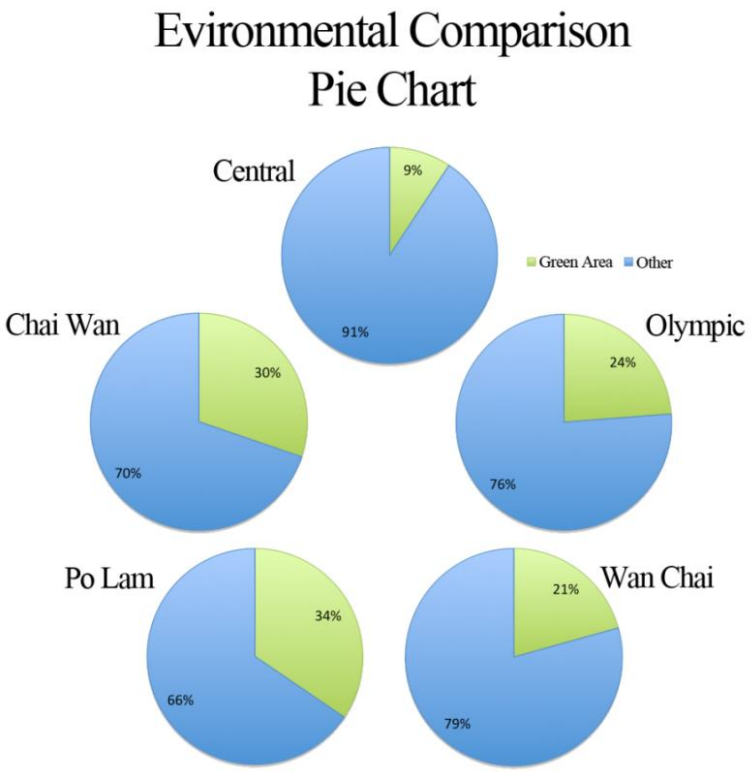

Figure 6.2.0
Green Area fraction comparison

6.4.2 Air Quality

Air quality measurement data for all five TODs can be found in the table and graph below. The individual Minimum and Maximum values for each exit can be found in the Appendix. In looking at the TOD averages, the five stations can be placed into three general groups. Po Lam's CO_2 levels were the lowest at 467ppm. Chai Wan and Olympic both had higher values of 523.13ppm and 518.50ppm. Central and Wan Chai had the highest CO_2 emissions corresponding to 552.90ppm and 561.80ppm, respectively.

Average CO2 Levels		
Location	**Average Value (ppm)**	**Deviation from Average**
Po Lam	467.00	-57.67
Olympic	518.50	-6.16
Chai Wan	523.13	-1.54
Wan Chai	561.80	37.14
Central	552.90	28.24
Average	524.67ppm	
Standard Deviation	57.17	
90% Confidence Interval	12.21	

Table 6.4.0
Average CO2 values and statistics

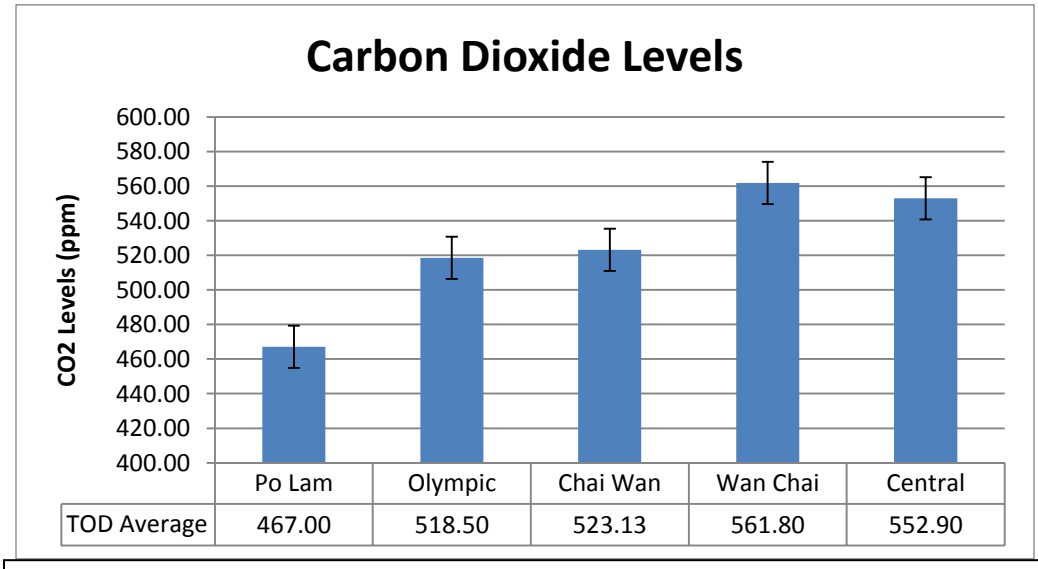

Figure 6.3.0
Average CO2 levels with 90% confidence interval

The overall population mean and standard deviations are also in table 4.0. 36 total data points were considered, and a 90% confidence interval was taken as ±12.21. The popular average and standard deviation were determined to the 524.67ppm with a standard deviation of 57.17ppm. Figure 6.3.0 presents this data graphically with the 90% confidence interval displayed as an error bar, the average values of each TOD are displayed at the bottom.

From Figure 6.3.0 we can see three general groups. Po Lam shows the lowest carbon dioxide levels with no overlap of the confidence interval. Olympic and Chai Wan display similar averages, and deviate less than 5% from the population mean. Wan Chai and Central show higher CO2 levels with no overlap with Olympic and Chai Wan.

6.4.3 Noise Pollution

Noise pollution data is provided in the table and chart below. The TOD specific averages are displayed in Table 6.5.0 and Figure 6.4.0. The independent variables are the TODs, and the dependent variables are the ambient noise levels in decibels.

Average dB Levels		
Location	**Average Value (ppm)**	**Deviation from Average**
Po Lam	65.00	-5.94
Olympic	71.20	0.26
Chai Wan	71.59	0.65
Wan Chai	72.61	1.67
Central	74.26	3.32
Average	70.93ppm	
Standard Deviation	6.13	
90% Confidence Interval	1.68	

Table 6.5.0
Average noise pollution levels with statistics

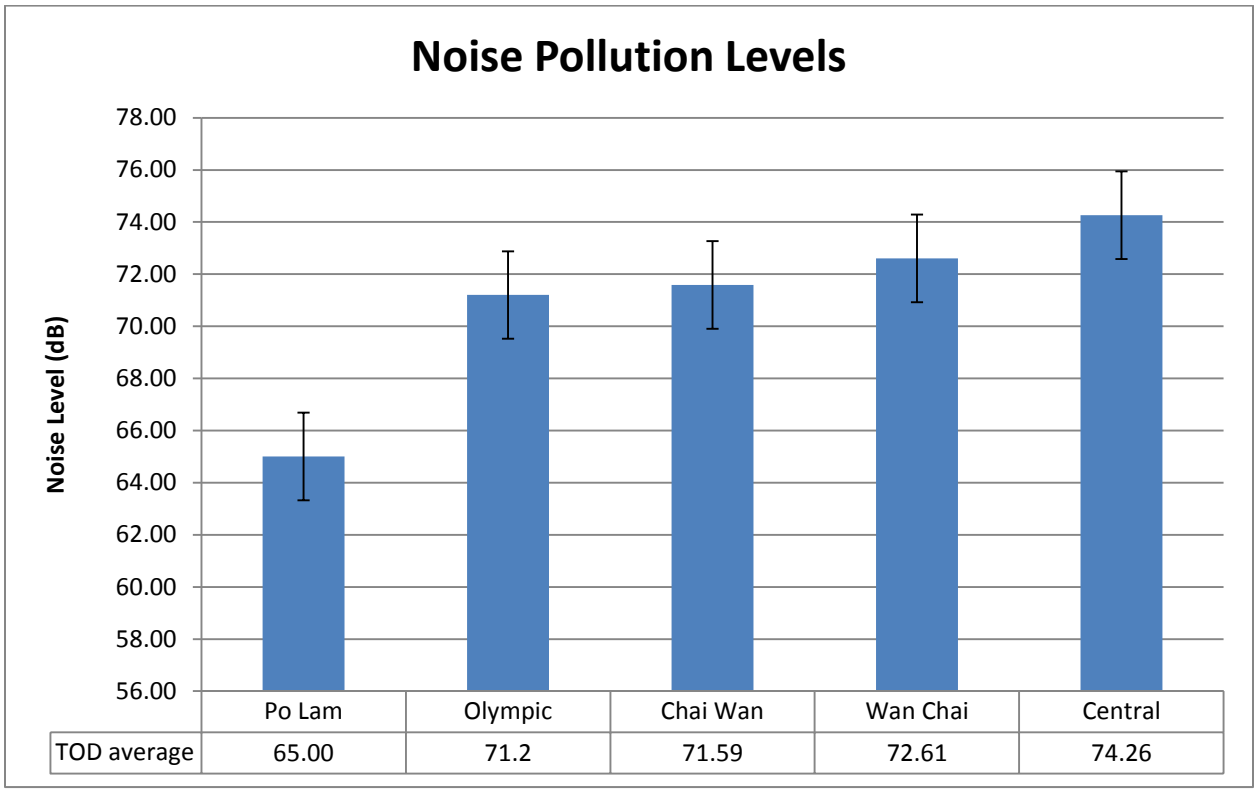

Figure 6.4.0
Average noise pollution levels with 90% confidence interval

The population mean of all data points was 70.93 decibels. This graph follows a similar trend to the air quality graph with Po Lam having the largest negative deviation of 6.0dB from the average. Olympic and Chai Wan once again have the smallest deviations from the average with 0.29dB and 0.65dB point above the above the average, respectively. Central had the highest positive deviation from the average at 3.32dB. A 90% confidence interval was constructed based on normalized data, and is seen in Figure 6.4.0. The width of this interval was determined to be ±1.68. The population mean was found to be 70.93dB with a standard deviation of 6.13. In Figure 6.4.0 the trend found in the air quality measurements is less clear. The intervals for Olympic, Chai Wan, Wan Chai, and Central have significant overlap. Po Lam in the only TOD with no overlapping confidence interval.

6.5 Economic Observations and Measured Data

We used the MTR station maps to find residential buildings in specific areas. The size of the map is 10×10 cells, which was divided by the MTR, we picked up 6×6 cells in the middle; the purple rounded signs, in Figures 6.4.1-4, show the locations of residential buildings. These buildings are the nearest ones in the overall TOD area. Figure 6.4.1 describes the Po Lam station. There are 9 commercial estates and 1 (No. 22) public housing building in this area. In Figure 6.4.2, we can see there are 5 commercial estates, and 2 public housing buildings in the definitive area of Chai Wan TOD. There are 5 more public housing buildings in the whole TOD, which are further away from the MTR station. Figure 6.4.3 is the Olympic TOD, No. 37 is the only one public housing building in this TOD, and 8 commercial residential buildings are located in the definitive part of the map. Figure 6.4.4 shows that there are only two commercial residential building in Wan Chai TOD area, but no public housing estate.

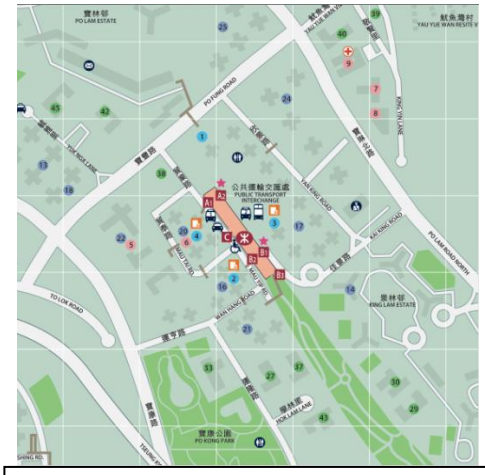

Figure 6.4.1
Po Lam Station

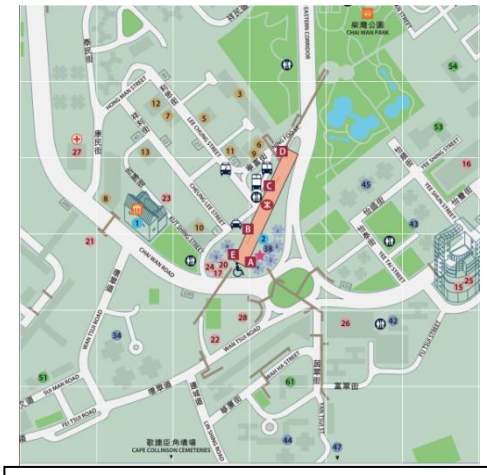

Figure 6.4.2
Chai Wan Station

Figure 6.4.3
Olympic Station

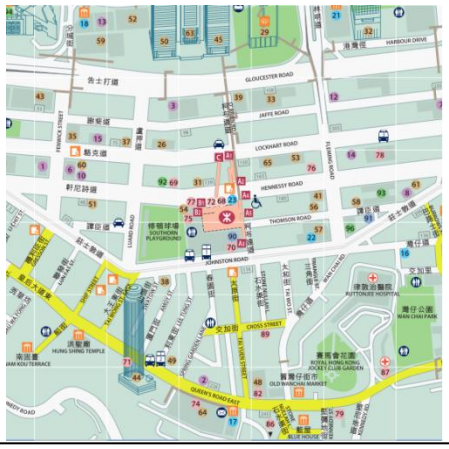

Figure 6.4.4
Wan Chai Station

6.5.1 Public Housing

By looking at the database of Hong Kong Housing Department, Hong Kong Housing Authority and the maps mentioned above, we figured out that Chai Wan has a high concentration of public housing buildings, and the highest population of lower class residents. From Table 6.5.0, we can see that the area of each public apartment is tiny, from 9.7 to 66.6 m^2, and in terms of the average area value among these buildings, we can figure the smallest one is called Verbena Heights located in Po Lam. The total amount of residents is around 50,000, only 2.5% of the total population of people who living in the public housing buildings. We found there are three types of public housing in these five TODs, they are Tenants Purchase Scheme Housing (TPS) and Public Rental Housing (PRH), provided by the Hong Kong Housing Authority; and the other type is Rental Housing of Hong Kong Housing Society (RHS), provided by the Housing society.

Public Housing							
Station	**Name of the Public Building**	**Type**	**Year for Opening to Public**	**Amount of Buildings**	**Amount of Units**	**Area of Units (m2)**	**Population**
Olympic	Hoi Fu Court	PRH	1999	5	2800	9.7-57.5	8400
Chai Wan	Fung Wah Estate	TPS	1991	2	400	34.7-66.6	1000
	Hing Man Estate	PRH	1982	3	2000	24.7-51.4	6100
	Hing Wah Estate	PRH	1976/1999	3/7	3600/2300	22.7-42.2 16.3-49.0	8400/7300
	Tsui Lok Estate	PRH	1999	1	300	22.9-60.1	800
	Tsui Wan Estate	TPS	1988	4	600	19.3-55.6	1700
	Wan Tsui Estate	PRH	1979	11	3700	22.5-58.1	10700
	Yue Wan Estate	PRH	1977	4	2200	22.7-56.2	6300
Po Lam	Verbena Heights	RHS	1996/1997	1	971	14.95-38.34	--

Table 6.5.0
Pricing of public housing buildings

6.5.2 Commercial housing prices

From the commercial housing prices found in the Centadata, we observed that the estates in Olympic station are the most expensive ones among the five TODs. In the Table 6.6.0, we can see that the lowest average price of the estates located in Olympic TOD is HK$5940.6971/ feet squared in 2009, it is about 1000 higher than the cost of one located in the Wan Chai TOD, the most expensive one among Wan Chai, Chai Wan and Po Lam TODs in 2009. The closer the estate is located to the MTR station, the more expensive it is. For instance, in the Table 6.6.0, Metro City I, II, and The Metropolis are the three estates closest to the MTR station, and their prices are higher than for the other estates, such as Finery Park, the furthest one and Ho Ming Court, next to the Finery Park. In terms of the average prices, we could find the tendency of commercial housing price. In Figure 6.5.0 the blue line shows the changes of average prices of the commercial housing estates in Olympic TOD, from 2008 to 2009, the average price went down in a small degree, and then the price rose up a lot from HK$7558.528 to 10089.44.

Commercial Housing Prices All Values in HKD					
Olympic Station					
	2008	**2009**	**2010**	**2011**	**2012**
Central Park	7512.59	7240.4	8361.16	10257.8	11327.33
Charming Garden	3234.5	3509.07	4045.85	4387.5	5395.08
Florient Rise	N/A	7230.29	8818.72	12067.34	12040.35
Fu Tor Loy Sun Chuen	3237.16	3575.42	4081.64	5232.55	6225.08
Harbour Green	8370.25	6814.05	7993.8	9276.64	10030.9
Island Harbourview	7201.76	6298.95	7925.7	9070.2	10213.47
Park Avenue	7414.71	6916.7	8839.55	13461.14	11358.75
The Hermitage	N/A	N/A	10401.8	14749.48	14124.53
Average	**6161.828**	**5940.697**	**7558.528**	**9812.831**	**10089.44**
Chai Wan Station					
	2008	**2009**	**2010**	**2011**	**2012**
New Jade Gardens	4064.88	4026.69	4962.65	6008.65	6581.91
Walton Estate	3430.33	3298.64	3654.53	4746	5295.15
Yan Tsui Court	2733	N/A	3118.83	4059	4454.33
Yee Tsui Court	3283	3221.83	3977	4630	5513.87
Yuet Tsui Court	N/A	3150	2120	2574	N/A
Average	**3377.803**	**3424.29**	**3566.602**	**4403.53**	**5461.315**
Wan Chai Station					
	2008	**2009**	**2010**	**2011**	**2012**
Southorn Garden	5527	4970.8	6234.66	7692.5	8841.5
Po Lam Station					
	2008	**2009**	**2010**	**2011**	**2012**
Finery Park	3096.9	2900.75	3649.08	4444.47	4965.29
Ho Ming Court	2586	N/A	3055	N/A	N/A
Metro City I	3873.33	3936.71	4394.7	5442.45	6270.18
Metro City II	4093.88	3839.44	4741.35	5552.55	6127.18
Radiant Towers	3130.57	2950.2	3413.5	4204.25	5042.4
The Metropolis	3840.23	3778.66	4619.82	5486.85	6206.87
The Pinnacle	3181.44	3341.4	3770.4	4699.33	5301
Yan Ming Court	2774.81	2829.14	3374	4025.75	4906.66
Ying Ming Court	2696.33	2583.9	3297.55	3942.13	4677.07
Average	**3252.61**	**3270.025**	**3812.822**	**4724.723**	**5437.081**

Table 6.6.0
Commercial housing prices

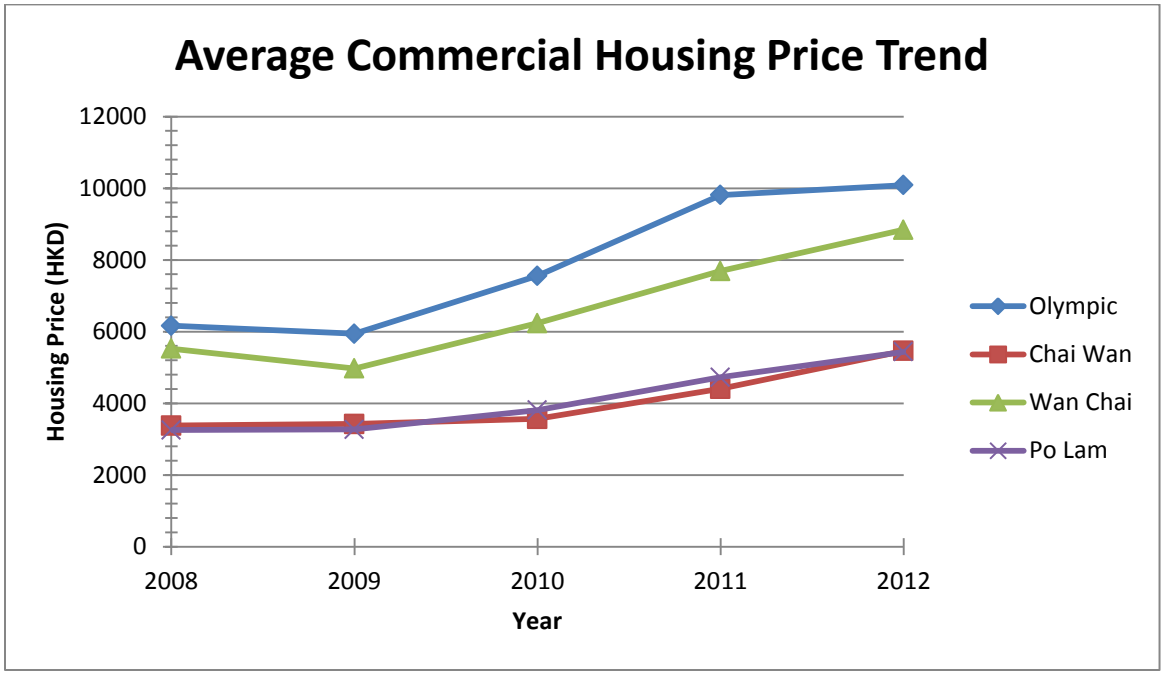

Figure 6.5.0
Commercial housing price trends

6.6 Residential Survey Data

The results of our surveys are shown in the following radio graph and tables. The radio graph compare the average values of each TOD for the questions answered, and the table displays the population mean for each question. A full survey is listed in the appendix, and the relevant questions are included in the accompanying table.

#	Questions	Average
1	How often do you use public transportation?	1.62
2	Do you find the area being excessively noisy?	2.61
4	Approximately how long does it take to walk to the train station?	2.34
5	Are the paths toward the station in good condition?	2.85
6	Do you feel like the walkways are congested?	2.65
7	I prefer living near the station	1.22
8	Do you feel like the station exits lead you to your destination?	3.1
9	Are you able to get your supplies near the station?	2.96
11	Do you feel like the area promotes a healthy life style	2.57
13	Do you feel like the area is aesthetically pleasing?	2.73

RED	1 = 7 days/week	4 = 0 days/week
BLUE	1 = Strongly Disagree	4 = Strongly Agree
GREEN	1 = less than 5 min.	4 = more than 20 min.

Table 6.7.0
Survey Population Averages

The aggregated results show normal small-sampled data. Results are clustered along the overall mean values for each TOD with no outlying points. No trimming was required of the dataset, and all survey responses were included. Table 6.7.0 shows the average multiple choice survey responses, with questions 3, 10 and 12 considered in a different section. Table 6.8.0 displays the deviation of each TOD from the mean. Red highlighted values are the largest negative deviation from the mean, and green highlighted values are the largest positive deviation

from the mean. One of the widest deviations occurred in the second survey question, "Do you find the area being excessively noisy". Po Lam's average fell 0.33 points below the overall mean, while Wan Chai's average was 0.55 points above the mean. Thus, Po Lam residents on average found their environment to be less offensively noisy than Wan Chai residents. Central residents had a moderate positive deviation, while Chai Wan and Olympic had moderate negative deviations. For question 7 "I prefer living near the station", a value of 1 was recorded as "yes" and a value of 2 was recorded as "no". The overall average for this question was 1.22, favoring the "yes" answer. Po Lam's average response was 0.18 points below the average, signaling more residents chose the "yes" answer. Wan Chai scored 0.16 points above average, corresponding to most "no" answers. Another notable result is question 6 "Do you feel like the walkways are congested?". Olympic and Po Lam both had a strong negative deviation of 0.21 points corresponding to low perceived congestion. Wan Chai had a strong positive deviation of 0.52 points corresponding to a much higher perceived congestion than average. Central and Chai Wan had more moderate results with smaller deviations which were negative and positive, respectively. Question 11 asked "Do you feel like the area promotes a healthy life style?". Olympic had the highest positive deviation of 0.19 points, with Central and Po Lam close behind with similar positive deviations. Chai Wan performed close to the overall average with a negative deviation of 0.01 points. Wan Chai produced a very strong negative deviation of -0.41 points.

DEVIATIONS FROM MEAN							
#	Question	Totals	Central	Chai Wan	Olympic	Po Lam	Wan Chai
1	How often do you use public transportation?	**1.62**	0.14	0.11	-0.18	-0.02	-0.06
2	Do you find the area being excessively noisy?	**2.61**	0.18	-0.25	-0.13	-0.33	0.55
3	Which of the following is your primary method for commuting to work?	**2.36**	0.1	0.12	-0.07	-0.12	-0.06
4	Approximately how long does it take to walk to the train station?	**2.34**	-0.02	-0.07	-0.1	0.1	0.09
5	Are the paths toward the station in good condition?	**2.85**	-0.25	0.19	-0.01	-0.05	0.11
6	Do you feel like the walkways are congested?	**2.65**	-0.15	0.08	-0.21	-0.21	0.52
7	I prefer living near the station	**1.22**	0.06	0.01	-0.02	-0.18	0.16
8	Do you feel like the station exits lead you to your destination?	**3.1**	-0.06	0.09	-0.1	-0.1	0.03
9	Are you able to get your supplies near the station?	**2.96**	0	-0.08	0	0	0.08
11	Do you feel like the area promotes a healthy life style	**2.57**	0.14	-0.01	-0.15	0.15	-0.17
13	Do you feel like the area is aesthetically pleasing?	**2.73**	-0.18	0.23	0.03	0.03	-0.57

Table 6.8.0
Survey mean deviations

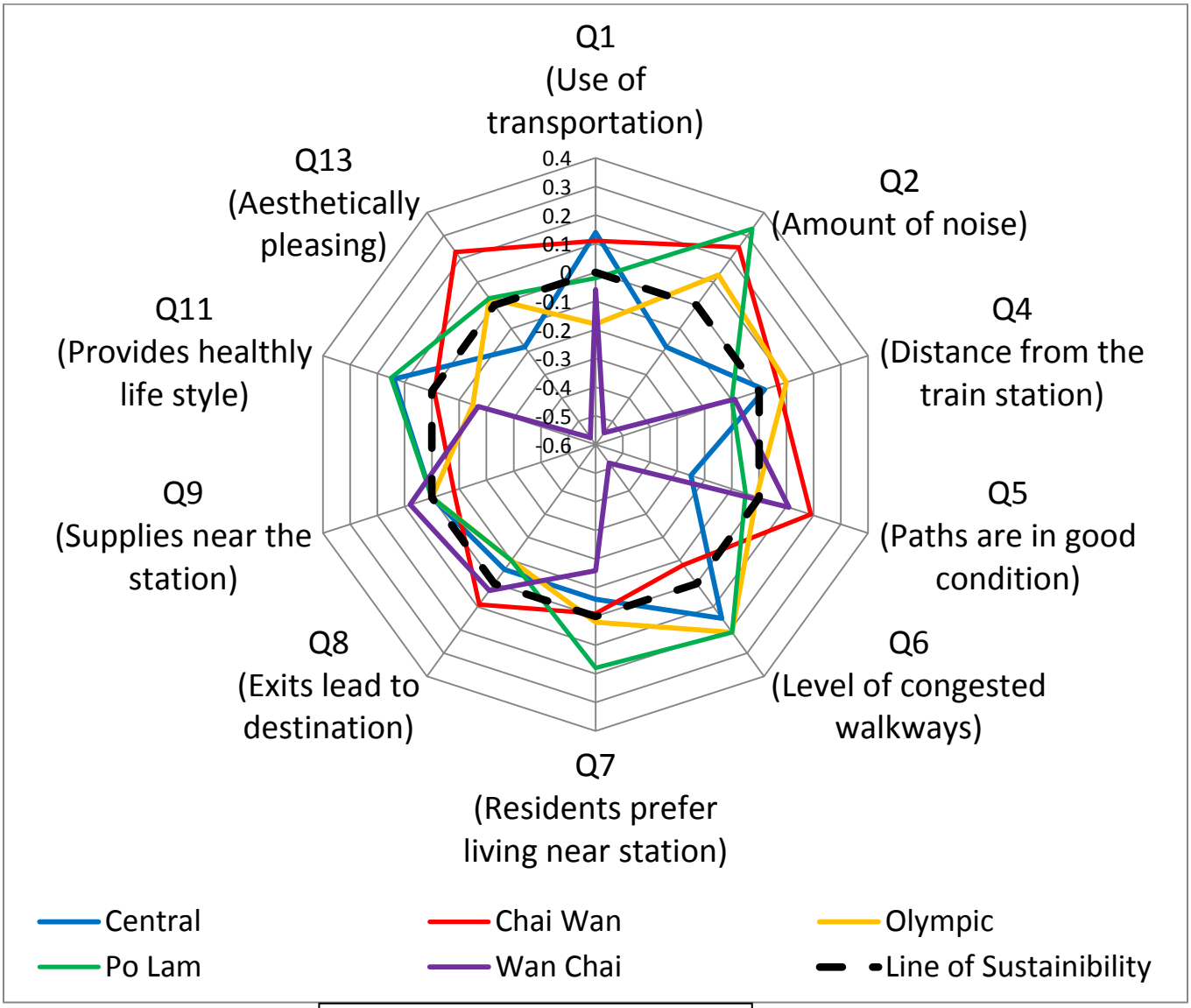

Figure 6.6.0
Survey response radiograph

Figure 6.6.0 is a visual display of Table 6.8.0. Each numbered point is a survey question, and the zero point is the mean for each question. Each TOD is color coded according to the legend. Lines furthest away from the center of the graph are more sustainable, since those questions displayed a positive deviation from the average. Lines closer to the center are less sustainable, since those questions display a negative deviation from the average. The Line of Sustainability is the population mean for each question. Points above the line represent positive deviations from the average, and points below the line represent negative deviations from the average. Wan Chai has the most negative deviations while Chai Wan and Po Lam have the most

positive deviations.

The data for questions 3, 7b, 10, and 12 are considered separately since they were open ended as opposed to multiple choice. These results were encouraged to be subjective to the survey takers, and a table of most repeated responses is found below. The full list of responses can be found in appendix F. Question 7b was a follow up to "I prefer living near the station" where the possible checkboxes were "yes" and "no", depending on their answer, the subjects were encouraged to give a reason for their choice. As shown in Table 6.9.0 the most common response was convenience in all five TODs. Po Lam especially had 17 of the 25 total respondents choose convenience. Subjects were less willing to elaborate why they chose "no", and the most popular response in this case was No Comment for all TODs except for Central, where 3 respondents out of 25 chose noisiness as the deciding factor.

Question 10 asked what services were missing from the TOD respondents were located in. The top two most common responses were listed in Table 6.10.0 No response was common for this question, and the reader is recommended to see the full list in the appendix. Public restroom use was the next most common response, especially in Central. Wi-Fi access, parking, and the need for a super market were also cited in Central, Olympic, and Po Lam respectively. The responses of question 12 were sporadic with no repetitions, and aren't considered here. A list is present in appendix F.

Question 7 Table			
Central	YES	Convenience	13
	NO	Noisy	3
Olympic	YES	Convenience	15
	NO	No Comment	5
Wan Chai	YES	Convenience	4
	NO	No Comment	6
Po Lam	YES	Convenience	17
	NO	No Comment	1
Chai Wan	YES	Convenience	3
	NO	No Comment	6

Figure 6.9.0
Survey question 7 results

Question 10 Table		
Station	**Services missing**	**People**
Central	Restroom	6
	Wi-Fi access	2
Olympic	Restroom	2
	Parking	2
Wan Chai	Restroom	2
Po Lam	Restroom	2
	Super Market	2
Chai Wan	Public Restroom	4

Figure 6.10.0
Survey question 10 results

Question 3 was a multiple-choice question which asked which form of transportation you primarily use. The four choices were walking, train, bus, car, and other. The results for the question are found in Table 6.110. In every TOD except for Central, train usage was the most common response by a margin of at least 28% of the total responses for each area. In Central bus use was cited slightly higher than trains. Overall, bus transit was the second most common mode of transportation with driving and walking receiving only marginal results.

Question 3 Table				
Station	**Walk**	**Train**	**Bus**	**Car**
Chai Wan	0	**14**	7	2
Central	0	7	**9**	3
Olympic	0	**18**	5	1
Po Lam	1	**14**	3	0
Wan Chai	0	**16**	7	0

Figure 6.11.0
Po Lam Station

6.7 Discussion and Validity

Fully defining a TOD is a complex task. Attempting to understand how many factors of each TOD go into determining if the area is sustainable is more of a challenge. For this project, we pulled resources from the background literature, two TOD researchers, Robert Cervero and John Renne. Mainly, we felt the work of Renne would be a good example of a methodology for conducting our research. Touching on each of the social, environmental, and economical factors of each TOD, Renne has compiled a detailed research base for examining the sustainability of a TOD.

However, while Renne provided the best framework for how to shape our research project, we still needed a place to start. Hong Kong has 87 different MTR stations. Due to the limited time we had in Hong Kong, we needed to figure which of these stations were considered to be TODs, and also which those TODs would offer us the most useful data. Fortunately, Cervero had already identified which of the stations were in fact TODs, but he was also able to categorize each TOD based upon the types of buildings in the area. From having found a list of possible TODs to examine, our group decided to choose 5 TODs with each belonging to a different category of Cervero's groupings. Once we had found a substantial footing, we were able to modify Renne's research methodology to suit our needs.

In order for our group to conduct a successful study of the five TODs, we needed to define what our constraints were. One of the biggest problems we faced during this project was the duration of our time in Hong Kong. Eight weeks' time was not sufficient to allow us to go into Renne's three sustainability aspects as deeply as we would have liked. Also, since there were only four members of our group, the lack of manpower proved to be a complication in data collection. Due to the fact that the amount of data we would be able to collect was limited, we had to be specific in selecting the important topics we thought were relevant to be included in our methodology.

Since we had limitations on how we collected data, some of our data's integrity was thus put into question. When conducting turnstile and station exit tests, since many of the stations would have more turnstiles/exits than there were group members, we needed to perform multiple trials. By conducting multiple trials, we could not provide an instantaneous snapshot of the pedestrian travel in the station. Also, due to the time constraints, we were not able to acquire as many trials for pedestrian flow data for the stations as we would have liked. Pedestrian flow measurements were taken at noon due to timing constraints across all 5 TODs. More trials throughout the workday would produce more typical and robust data. This would provide more data resulting in stronger trends to be used in comparison.

Noise pollution and air quality data was taken according to professional testing standards with scientific equipment. Despite proper data collection technique, the duration with which we were given the equipment and time restraints prevented a fully robust analysis. Testing could have been done over multiple days in order to improve the validity of the trends we observed.

Another problem which arose when conducting this abridged research project, was the amount of data collected from surveys. Unlike in Renne's project where his team was able to collect data from thousands of surveys made mandatory by the Australian government, we were able to only to process 25 surveys per TOD, totaling 125 surveys overall. Also, because we could not afford to wait for responses from the area's residents to be mailed to us, we needed to have the surveys filled out on the spot. By distributing them ourselves we were able to receive immediate responses that were not as free from bias as a mailed survey. In many cases, the translators would read the survey to participants, and may have slightly biased some answers.

By devising a broad and comprehensive methodology, we were able to collect enough data to construct a detailed comparison of the five TODs studied. Focusing on Renee's three aspects of sustainability allowed for a flexible methodology, capable to be applied in other TODs internationally. The combination of observations, measurable data, and surveys provided

consistent results that could be cross-checked to minimize any misstep in judgment. For example, many of the survey questions asked for resident opinions on data we collected. This ensured our observations and measured data were consistent with the needs of residents, our primary affected party. Due to the time duration of our study and resources, many of our methods could have been completed in more detail, with more data providing a strong correlation between results and conclusions; however, the methodology we devised was sufficient for an exploratory study.

7. Conclusions

In order to assess the sustainability of TODs in Hong Kong, five stations were chosen according to Cervero's study. These stations were Central, Chai Wan, Olympic, Po Lam, and Wan Chai. Our observations have shown that these stations exhibit a variety of differing characteristics. The physical design of the station, location, and built environment have a tremendous effect on the sustainability of these areas. The first goal of this research was to analyze these five typical stations, and determine in what ways each station succeeds or fails in the three fundamental components of sustainable living: environmental, social, and economic sustainability. It was not meaningful or possible to describe any of these TODs as being the "best". Considering the amount of indicators studied, and the effect of time constraints on the study, these conclusions are inherently limited. However, we believe that there are many significant and meaningful conclusions that can be drawn from our collected data.

7.1 Social Sustainability Comparisons between each TOD

Evaluating social sustainability relies on the resident's perception of their own surroundings as well as the integration of public transportation within the area studied. This data was gathered through our surveys, observations, and measurements. Pedestrian congestion and station flow rates provided us with quantitative results to support our survey responses. In addition, photographic evidence of sustainable and mixed-use buildings and services were provided to supplement conclusions drawn on walkability and independence of the TOD.

7.1.1 Olympic and Central

From pedestrian flow rates and sidewalk width data, Olympic and Central were plagued by poor walkability and congestion. In the case of Central, this may be partly explained by the age of the area. As one of the oldest areas in Hong Kong, it suffers from overcrowding. Despite

the amount of overhead bridges designed to relieve some of the congestion, it is not sufficient to properly dissipate the walking traffic. Olympic Station has a unique geographic condition that limits its walkability. Olympic Station is located close to Tai Kok Tsui and Mong Kok. Due to the connections with the Red and Orange MTR lines, Olympic has become a transportation nexus and major shopping destination with the Olympian City mall. The walkability within the station and Olympian City was designed to be highly extensive, and our pedestrian flow and sidewalk data supports this argument with having large width sidewalks. From survey response data, Olympic residents found their area highly walkable, with low congestion. Unfortunately, once one leaves the Olympian City, the walkability and congestion become an issue due to the older neighborhood of Tai Kok Tsui and the crowding of Mong Kok. The differences in Tai Kok Tsui sidewalk width and Olympic station thoroughfares are immediately apparent to travelers, and shown in the photographic data in Appendix B.

7.1.2 Wan Chai

Wan Chai contains a higher residential density from our commercial housing data, but is far more walkable than both Olympic and Central. The TOD area of Wan Chai was mostly built in the reclaimed area of the bay, and despite the age of the area, it was designed to better dissipate foot traffic. The physical size of the Wan Chai station, however, was insufficient for the population of the TOD area. Congestion within the station was a major issue, which was remediated through the variety of exits structured to properly dissipate pedestrians. From our pedestrian flow data, Wan Chai had the largest amount of foot traffic. Out of the five TODs, Wan Chai residents were the most likely to claim that the MTR station exits led residents to their destinations than on average. Wan Chai residents were also the most likely to claim their paths were in good condition.

7.1.3 Chai Wan and Po Lam

Chai Wan and Po Lam were by the most walkable according to our analysis, and had the least amount of congestion due to less foot traffic. Despite the population density of these two areas, station exits and ground level walkways were designed to funnel travelers and residents in the most efficient manner. Neither station was excessively crowded, due in part by larger width sidewalks. Po Lam in particular had a balanced exit design, which corresponded to residents claiming low congestion levels. In Po Lam, two large exits to the mall, a ground floor exit, and a walkway directly into a linear park were sufficient for the amount of foot traffic present.

7.2 Environmental Sustainability Comparisons between the TODs

7.2.1 Green Areas

Environmental sustainability was evaluated using green area fractions, air quality, and noise pollution measurements. Central once again suffers from its age, and contains very little green area, having only 9%. Despite many small parks in the district, the green area fraction pales in comparison to Po Lam and Chai Wan, having 34% and 30% respectively, which featured prominent parks and recreational fields. Po Lam in particular contained many parks that were integrated into the surrounding area, as shown in our photograph section. Olympic station succeeded in maximizing green area through rooftop parks including prominent parks on the roof of Olympian City II and on the roof of the HSBC building. The area around Tai Kok Tsui also contained many large parks among the residential buildings, thus summed up to a sizable 24% green fraction.

7.2.2 Air Quality

Air quality measurements reflected the effects of green areas and a clustered built environment. Borrego's paper modeled the effects of city planning and its effect on CO_2 levels within the city. Compact areas with mixed-use buildings and open corridors for airflow better

dissipated CO_2 levels. Po Lam had the lowest CO_2 emissions even with a 90% confidence interval. Central and Wan Chai scored above Olympic and Chai Wan with some overlap of confidence intervals. This can be partially explained by three major factors. First, the significant amount of green area, not just around the TOD, but also integrated directly into the built environment sequesters CO_2 by photosynthesis. Second, the compact design coupled with very wide sidewalks and residential skyscrapers spaced enough for adequate airflow were predicted by Borrego to help dissipate CO_2 levels. Finally, proximity to the ocean provides strong crosswinds and a natural CO_2 sink. Both Central and Wan Chai lie along the heavily developed Northern side of Hong Kong Island, corresponding to increased traffic and the older, more cramped urban environments are less efficient at dissipating accumulated CO_2.

7.2.3 Noise Pollution

Noise Pollution levels were taken around each station, and once again Po Lam had the lowest average value than any of the other stations with a 90% confidence interval. This can be particularly explained by the decrease in automobile traffic. In the other TODs, especially at the street level, bus and automobile traffic contributed to excess noise pollution. Po Lam, even at street level had lower noise levels, whereas the other stations had similar values. Wide open sidewalks help minimize echoing when walking through the streets. Survey results supported these claims as resident input helped add breadth to our study. Po Lam residents were the most likely to claim low noise levels and a healthy lifestyle, which is justified from our measured noise and air quality data.

7.3 Economic Sustainability Comparisons between TODs

Economic sustainability was considered from expected housing prices for both public and commercial housing. In terms of the concentration of public housing areas and low-income housing, Chai Wan had the greatest concentration of these buildings. The Olympic City was

specifically marketed to be high-class apartments and features the most expensive living arrangements. Central had no apartment buildings, and was completely excluded from this analysis. Central exemplifies an office building focused TOD, and as a result does not contain significant residential living. In terms of mixed housing prices, Po Lam and Wan Chai had the best mix of different housing prices. These followed a trend of going from less expensive to more expensive as the distance to the MTR station becomes shorter. In addition, despite the slight drop of housing prices between 2008-09, prices in the areas have been steadily on the rise, becoming les sustainable for residents.

7.5 Summary of Conclusions

In terms of providing a sustainable environment for residents, the Po Lam TOD provided a wealth of services, a positive resident response, environmental sustainability, and many economic opportunities. Po Lam was a newer built TOD with transit-oriented sustainability in mind. Despite this, residents were less likely to claim that they were able to find all their necessary services without traveling to another TOD, leading to a loss of independence in the area.

Olympic station was also constructed more recently than the Hong Kong Island TODs, but with less undeveloped spaced as Po Lam. Despite this limitation, Olympic was able to provide a sizable 24% green area through creative green walkways and rooftop parks, shown in our Appendix B photographs. Olympic residents were eager to comment on the low congestion of The Olympic City mall, the short distance from the MTR station, and the low noise levels. The walkability was improved in spite of a challenging geographic design by long connecting walkways that led residents and visitors to their necessary locations.

As we compared the social, environmental, and economic sustainability of living and working conditions in five different TODs, we found Po Lam to excel in walkability and green

area, as well as having the lowest CO_2 and noise pollution levels. The surveyed residents of Po Lam generally agreed with our observations. Po Lam residents were the most likely to state they enjoyed living in a TOD, and described their area as promoting a healthy lifestyle. We found through observation that Olympic station was the best at dissipating pedestrian traffic due to its wide walkways, and clearly marked exits. Despite large amounts of people going through the Olympian City mall, Olympic residents were just as likely to describe their TOD as not as congested as Po Lam, which had less pedestrian traffic. The two newest developments, Olympic and Po Lam, scored higher in environmental sustainability than the older three developments studied. Of these three older developments, Chai Wan was the most environmentally sustainable as determined both by observation and survey response. Chai Wan residents were the most likely to find their area aesthetically pleasing of all the TODs studied. A sizable green area combined with low air and noise pollution levels bolstered the resident's satisfaction. Chai Wan suffered from a similar problem as Po Lam where residents felt their area was less independent of other TODs due to the focus on residential housing. Wan Chai scored much lower in environmental sustainability, but from a social and economic standpoint was the most independent of all developments. Wan Chai featured a blend of housing, offices, and provided a variety of services within the walkable area for residents. Wan Chai residents were the most likely to list their area as providing all essential services in close proximity to the station. In addition to confirming the uniqueness of each area, these findings provide information crucial for the improvement of these urban environments, and for planning new developments.

8. Recommendations

Hong Kong's urban environment has provided us with a wealth of information, allowing for a meaningful comparison of sustainable living indicators in Central, Chai Wan, Olympic, Po Lam, and Wan Chai TODs. From the offices hustle and bustle of Central, to the picturesque residential life of Po Lam, urban life takes on many different forms. These areas have historically been built and developed along with the expansion of the MTR, the crucial artery of Hong Kong living. From our survey results, 48% of residents reported using the MTR 7 days a week and an additional 42% reported using the MTR 4-6 days per week. It is not surprising to see such high usage rates in the areas around these stations. When surveyed, 65% of residents reported using MTR rail as their primary method of transportation. In Central, residents of distant TODs used the MTR to get to work every day. In Po Lam, local residents used the MTR to commute to their offices. Whether living or working in a Hong Kong TOD, the MTR provides a connection to every other TOD.

When evaluating these developments we found that each TOD performed differently. No development was a utopia, but none performed radically worse than the others in all five categories (green area, walkability, congestion, housing opportunities or pollution levels). We found each TOD had room for improvement in terms of its sustainability indicators, as we defined them. From these conclusions, two overlapping sets of recommendations could be developed: recommendations for new TODs, and recommendations for improving the sustainability of existing TODs. When considering new TODs, we offer our methodology as a toolbox for assessing TOD sustainability beyond Hong Kong.

8.1 Recommendations for Existing Developments

For improving the sustainability of existing developments in Hong Kong, our study will be relevant to all TODs in Hong Kong. The five TODs we studied represent all five of Cervero’s

classifications. From this, we make a series of generalized recommendations that can be applied to a variety of Hong Kong TODs.

Firstly, improving the integration of green areas with mixed-use buildings is the most critical for improving many sustainable aspects for residents. In addition, walkability in the area surrounding the station, as well as the TOD in general must be thoroughly improved to both dissipate congestion as well as better connect the area at large. Finally, the areas surrounding the station must be aesthetically pleasing to both residents and visitors, because without a centralized area that residents can be proud of, the sustainability of the TOD in the eyes of the population will suffer.

Chai Wan, Central, and Wan Chai were originally built before sustainable design was fully implemented. Yet, there have been many changes in these areas to improve their sustainability despite the physical constraints of an existing built environment. Central and Wan Chai face the most constraints to sustainable improvement. However, there are many lessons they can learn from the other TODs. Central TOD primarily suffers from a small green area, and street-level congestion. Public and private initiatives have been enacted to improve the green area acreage around Central, but we recommend an additional method. Olympic station's blend of rooftop parks along with smaller street-level parks have shown to be very effective. Overhead walkways have been the greatest asset to dissipating pedestrian congestion as well as improving walkability. We recommend the construction of overhead green walkways in Central to remedy both of these shortcomings. In Wan Chai, the aesthetic quality and pollution of the area were of chief concern to residents. Through smaller-scale urban renewal projects focusing on providing a more picturesque façade, residents in Wan Chai will take more pride in their living environment. In addition, by planting more leafy trees, the noise levels can be reduced and the air quality can be improved. Similarly to Po Lam, the integration of green areas with the built environment has a

strong effect on improving the sustainability of the area, as well as on improving the area's aesthetic appeal.

Olympic TOD has suitable green areas, but can be better integrated with Tai Kok Tsui and Mong Kok. Currently, it exists as an oasis of upper-class sustainable living juxtaposed in the surrounding areas. As such, social sustainability drops off as soon as one leaves the Olympian City due to lower walkability in the surrounding areas. To remedy this, we recommend a smoother blending between The Olympian City and Tai Kok Tsui through mixed-use sustainable buildings in the area outside of The Olympian City. In additions we recommend urban renewal efforts in Tai Kok Tsui that preserve local heritage. This would provide improved walkability in the developing transitional area.

In the cases of Po Lam and Chai Wan, they relatively had the fewest setbacks in comparison to the others. Residents of these areas wanted greater independence from the surrounding areas. Many cited the need for additional food markets, restaurants, and doctor's clinics in the walkable area. The infrastructure is already fully in place for these components, and we recommend the Sino Group, which owns the major TOD malls, increase the variety of shops to provide for the needs of residents.

Existing Hong Kong TODs are generally cited by residents to require additional green spaces and to improve the walkable area around the MTR stations. By improving walkability, providing independence from other TODs with a mixture of services, and constructing aesthetically pleasing green areas, the sustainability with respect to residents will be improved.

8.2 Recommendations for New Developments

Considering new developments outside of Hong Kong, a carefully performed comprehensive study based upon our methodology is strongly recommended. The economic,

environmental, and social aspects of sustainability carry over into international TODs. With our methodology grounded in these aspects, our comparison of Hong Kong TODs provides a framework for making recommendations in new developments. In the design of new TODs, whether in Hong Kong or internationally, the presence of mixed-land use and rail transit focus should form the backbone of a successful development. In order to make this development sustainable, all three of the sustainability aspects must be prioritized. The rail station must be the central nexus of the development; it will likely be the most congested area and thus requires exceptional walkability. Each station exit must dissipate the flow of residents efficiently and without unnecessary or excessive paths. Green areas must not only be prominent, but also heavily integrated with the entire area. Integration of green areas allows for parks and recreational fields to contribute directly into walkability and pedestrian flow in the TOD walkable area. By prioritizing a compact yet spacious design in conjunction with an integrated green area, air quality levels will be improved. Finally, mixed-housing prices will provide for economic opportunity and the potential for sustained growth in the future.

The recommendations for existing developments provide some overlap into the new developments. By learning from the existing Hong Kong TODs, lessons can be learned and applied to the new developments. The recommendations for existing developments, as a result, exist to provide additional information for those planning new developments, both within Hong Kong and abroad.

We have outlined a few major recommendations for the TODs studied, new TODs to be constructed both in Hong Kong and internationally, as well as improving existing developments. We have determined that Renee's indicators are well-suited as a starting point in designing a comprehensive methodology. Cervero's pioneering work classifying TODs in Hong Kong also provided a suitable guideline for the study of the area.

8.3 Significance of Recommendations

We believe that the recommendations that we have proposed in this report are beneficial to improve Hong Kong's social fabric, and they are feasible to accomplish. While Hong Kong population is rising, the need for additional housing needs to be addressed. If the Hong Kong government wishes to use up more of its land in the New Territories, it would be in its best interest to build a TOD. Starting on undeveloped land, it will allow for more flexibility in design. Having this freedom allows for the developers to form a community that looks more like Po Lam, and less like Wan Chai. The greatest advantage for having to build a new TOD is that it will allow the area to have a substantial integrated green environment. This is important because many of Hong Kong's current TODs fail to accommodate a sizeable amount of green area within its walkable boundaries. By starting from scratch, the developers can create a community that will have a perfect blend of the number of residents, businesses, and environmental parks in an area, which has easy access to the MTR.

However, there are a few drawbacks to building a new community. The most important factor is cost. In order for the government to develop the land into residential housing, office buildings, malls, parks, and a station; it would have to spend a sizable amount. The size of the investment along with the enormity of the project has a huge risk. Since it would take a few years for the TOD to come to fruition, many problems such as construction errors can occur. Also, it could take years even after the area has been fully constructed for it to develop an economic identity without having a stable community in place. Due to the developable land shortage in Hong Kong, every available acre must be built as efficiently as possible. We believe that sustainable design as we have defined it, is a critical aspect of new developments.

The most practical and immediately applicable part of our recommendations would be to improve the existing TODs. Since many of the existing TODs have already developed in an urban setting, it would be difficult to make sweeping changes due to land and zoning restrictions.

However, many of the TODs we studied could make minor adjustments. This includes improving upon the environmental qualities such as green walkways and rooftop parks. We suggest changes at an environmental level because it would be unrealistic to have an area change in regard to its housing demographic without the consent of government and real estate parties. All TODs we studied use nearly every square inch of developable land. Such large scale infrastructure changes become infeasible due to the number of parties involved.

Our assessment of sustainability has shown that the majority of TOD residents are quite happy with their way of life. They enjoy the convenience that TODs offer, but they still want more minor improvements, and these improvements for TODs also serve as lessons internationally.

8.4 Concluding Remarks

As a result of this research, we have found that environmental sustainability has the greatest effect on resident satisfaction and quality of life. In survey responses, residents in general commented on improving the aesthetic quality of their environment, as well as on lowering pollution levels. Walkability was the next most important factor to residents who were surveyed. Po Lam and Olympic prioritized integrated environmental design, which included parks and recreational fields with other mixed-use buildings. This resulted in positive survey responses, which were in turn supported by our observations. Not only does an environmental focus ensure better resident satisfaction, it improves the air quality and noise pollution within the development. A strong causal relationship was established between the green area around the housing developments and air quality. Air quality remains a major concern both in Hong Kong and anywhere else in the world, and we recommend combining walkable and green infrastructure as a possible solution. Overhead walkway parks and green rooftops have contributed positively

in Olympic, despite limited undeveloped ground level space. We recommend measures such as efficiently developing green areas. These measures are feasible for older developments such as Wan Chai and Central as well, which have limited space

Full integration of a green environment with a TOD to the extent accomplished by Po Lam, is not feasible in existing developments due zoning and property rights. But in a new development, integrating green walkways and parks within the walkable area is critical to improving both sustainability and resident satisfaction. In planning any new development, TOD self-sufficiency must be stressed to ensure economic and social sustainability for the area. Wan Chai excels in providing mixed-use buildings and all essential services for residents in a walkable area. By blending superior walkability around a transit hub, a pleasant walkable area, integrated environmental design, and mixed-use housing; we define the scope of what actually makes for a sustainable TOD.

While we have identified major sustainability factors such as green area, walkability, mixed-use buildings, pollution, resident satisfaction, and station design; there remain other indicators to be studied by future researchers. These include waste management and study of small businesses in the area within TOD boundaries. These indicators are present in Renne's research, but were not considered in this paper. Focusing on more of Renne's indicators would go deeper into the environmental and economic aspects of TODs, and build upon our current research. In addition, a more rigorous survey methodology would provide more accurate data, and potentially uncover additional sustainability indicators.

The current state of urban living in Hong Kong's Transit-Oriented Developments is very favorable. The MTR's continued growth and profits provide a sustainable lifestyle for the residents of one of the most densely populated cities in the world. Developments such as Po Lam

and Olympic could serve as models for TOD planning throughout the world. Olympic in particular has shown how a traditional residential area can be improved and made more sustainable by integrated with a TOD. Our recommended interventions could help other Hong Kong developments improve to become more sustainable as well.

Taking the conclusions we have drawn in Hong Kong, we can apply our recommendations to TODs abroad. Our research revealed how integrated urban planning efforts with a focus on sustainability could improve the quality of life for residents, and should be prioritized in the planning of new TODs. The methodology which we have developed is comprehensive enough to help plan developments throughout the world. Through assessing the sustainability of Transit-Oriented Developments in Hong Kong, we have provided a list of recommendations capable of improving the quality of life for residents both in Hong Kong and abroad.

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10. Appendices

Appendix A: Pedestrian Data

A. Turnstile Data

Po Lam

Turnstile 1 – B side

IN	OUT
Kevin – 114	Brandon – 34

Turnstile 2 – A side

IN	OUT
Dwight – 84	Mengxi – 41

Central

Turnstile 1 –

IN	OUT
Brandon – 259	Mengxi – 233 Dwight – 269 (take average)

Turnstile 2 –

IN	OUT
Brandon – 64 Mengxi – 124 (add)	Dwight – 75

Turnstile 3 –

IN	OUT
Brandon – 17	Dwight – 94

Chai Wan

Turnstile 1 – A side

IN	OUT
Brandon – 122	Dwight – 99

Turnstile 2 – D Side

IN	OUT
Brandon – 67	Dwight – 29

Wan Chai

Turnstile 1 – Closest to exit A3

IN	OUT

Brandon – 154	Mengxi – 90 Dwight – 84 total – 174

Turnstile 2 – Between the other two turnstiles

IN	OUT
Brandon – 97	Mengxi – 164 Dwight – 146 (average)

Turnstile 3 – Furthest from the exits

IN	OUT
Brandon – 60 Kevin – 7 Total = 67	Total = 47

Olympic

Turnstile 1 – Olympic City 1 side

IN	OUT
115	78

Turnstile 3 – Olympic city 2 side

IN	OUT
70	74

For the Olympic test we did two people per entrance/exit and the values were the same for each person, therefore these numbers listed above are both the average and the amount we counted.

B. Street Pedestrian Data

Central

Connaught Bride – Going to Hong Kong Station = Brandon – 275 Dwight – 280
– Going to Central Station = Kevin – 247 Mengxi – 237

Chai Wan

Exit A –IN – Dwight – 111
OUT – Brandon 96

Exit B – IN – Brandon – 99
OUT – Dwight – 73

Exit C – IN – Brandon – 59
OUT – Dwight – 36

Exit D – IN – Brandon – 45

OUT – Dwight – 25

Exit E – IN – Dwight – 79
OUT – Brandon – 66

Olympic

Exit A Bridge – IN – Dwight – 67
OUT – Brandon 34

Exit B Bridge – IN – Dwight – 43
OUT – Brandon – 47

Exit C Bridge – IN – Dwight – 40
OUT – Brandon – 43

Exit D Bridge – IN – Dwight – 177
OUT Brandon – 173

Exit E Bridge – IN – Dwight – 57
OUT – Brandon – 65

Tai Kok Tsui Road – Brandon – 498
Dwight – 489
Mengxi – 482

Po Lam

Exit B3 – IN – Dwight – 33
OUT – Brandon – 19

Exit B2 – IN – Brandon – 94
OUT – Dwight – 136

Exit A1 – IN – Brandon – 106
OUT – Dwight – 138

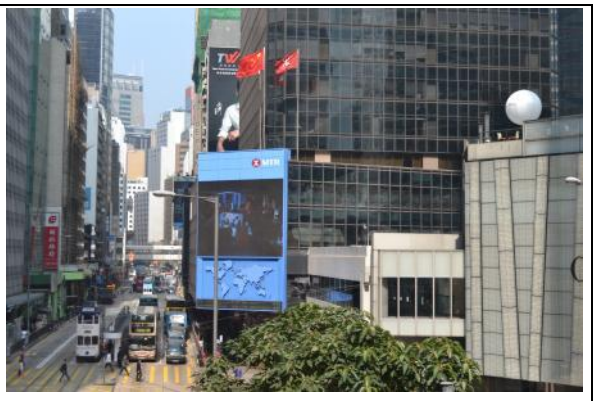
Wan Chai

Government Bride – Brandon – 640 Dwight – 620 Kevin – 604 Mengxi – 598
(Dwight and Brandon counted pedestrians headed towards the government building)

5 Gloucester Road sidewalk flow – 26
(Brandon, Dwight, Mengxi present)

Appendix B: Photographic Analysis

A. Central

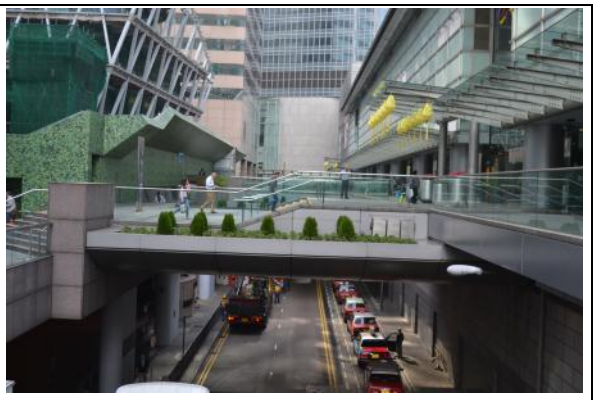


Picture A-1: MTR Station

Picture A-2: Walkway bridge connecting from MTR to Landmark

Picture A-3: Walkway bridges connecting to Landmark

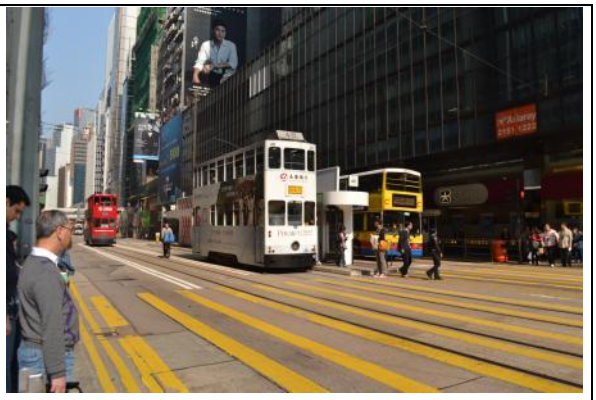
Picture A-4: Walkway bridge above Connaught Rd.



Picture A-5: Walkway bridge connecting to IFC Mall

Picture A-6: Walkway bridge connecting to Hong Kong Park

Picture A-7: Crosswalk on 20 Pedder St.



Picture A-8: Light Rail

Picture A-9: Office buildings on Connaught Rd.

Picture A-10: HSBC building and other office buildings

Picture A-11: More office buildings

Picture A-12: Hong Kong Park

Picture A-13: Chater Garden

Picture A-16: Central Fire Station

PictureA -14: Central Government Offices

Picture A-17: The Landmark

Picture A-15: Post Office

Picture A-18: IFC mall

B. Chai Wan

Picture B-1: Chai Wan MTR Station

Picture B-2: Walkway bridge connected to MTR

Picture B-3: Inside the walkway bridge

Picture B-4: Sidewalk in Chai Wan Park

Picture B-5: Walkway bridge and cross walk at Yee Tai St.

Picture B-6: Taxi Stand

Picture B-7: Light Bus Station

Picture B-8: Residential Area

Picture B-9: Chai Wan Park

Picture B-10: Chai Wan Park with some residential buildings

Picture B-11: Yee Tai St. Park

Picture B-12: New Jade Shopping Arcade

Picture B-13: Shops

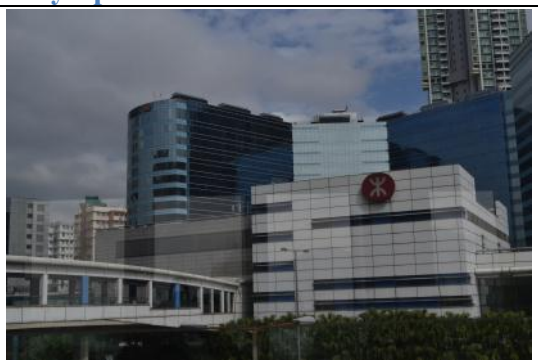
Picture B-16: College

Picture B-14: Chai Wan Sports Center

Picture B-17: Hospital

Picture B-15: Youth Square

C. Olympic



Picture C-1: Olympic MTR Station

Picture C-2: Walkway bridge connecting from MTR to HSBC

Picture C-3: Inside the walkway bridge connecting to HSBC

Picture C-4: Inside the walkway bridge connecting to Olympian City 1

Picture C-5: Tai Kok Tsui St.

Picture C-6: Escalator in HSBC going to MTR

Picture C-7: Olympian City

Picture C-8: Taxi Stand

Picture C-9: Bus Terminal

Picture C-10: Residential area

Picture C-11: The Hermitage

Picture C-12: Olympian Park

Picture C-13: Playground in Olympian Park

D. Po Lam

Picture D-1: Po Lam MTR Station

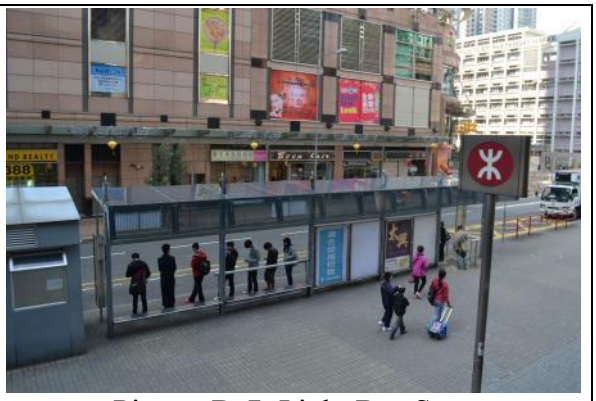
Picture D-2: Mau Yip Rd.

Picture D-3: Walkway bridge on Po Fung Rd.

Picture D-4: Inside of the walkway bridge on Po Fung Rd.

Picture D-5: Walkway bridge connecting from MTR to Metro City 1

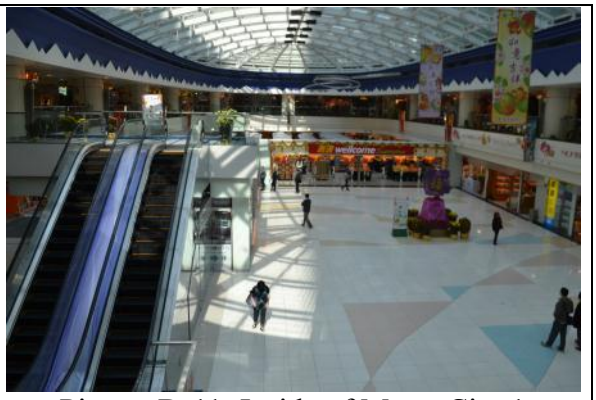
Picture D-6: Taxi Stand



Picture D-7: Light Bus Stop

Picture D-10: Po Lam Shopping Centre

Picture D-8: Bus Terminal



Picture D-11: Inside of Metro City 1

Picture D-9: Metro City mall

Picture D-12: Residential area

Picture D-13: Po Tsui Park

Picture D-16: Bicycle Trail in Po Lam

Picture D-14: Playground in Po Tsui Park

Picture D-17: The Pinnacle

Picture D-15: Exit B3 Walkway

Picture D-18: Po Lam Fire Station

Picture D-19: Po Lam Market and Post Office

E. Wan Chai

Picture E-1: Wan Chai MTR Station

Picture E-2: Walkway Bridge on Hennessy Rd.

Picture E-3: Inside of the walkway Bridge on Hennessy Rd.

Picture E-4: Walkway bridge on Queen's Road East

Picture E-5: Walkway bridge on Gloucester St. and Route 4

Picture E-6: Crosswalk on Hennessy Rd.

Picture E-7: Light Rail

Picture E-8: Bus Stop

Picture E-9: Wan Chai Ferry Pier and Expo Promenade

Picture E-10: Residential area on Queen's Road East

Picture E-11: Office buildings

Picture E-12: Residential area

Picture E-13: Wan Chai Park

Picture E-16: Government buildings

Picture E-14: Southorn Park

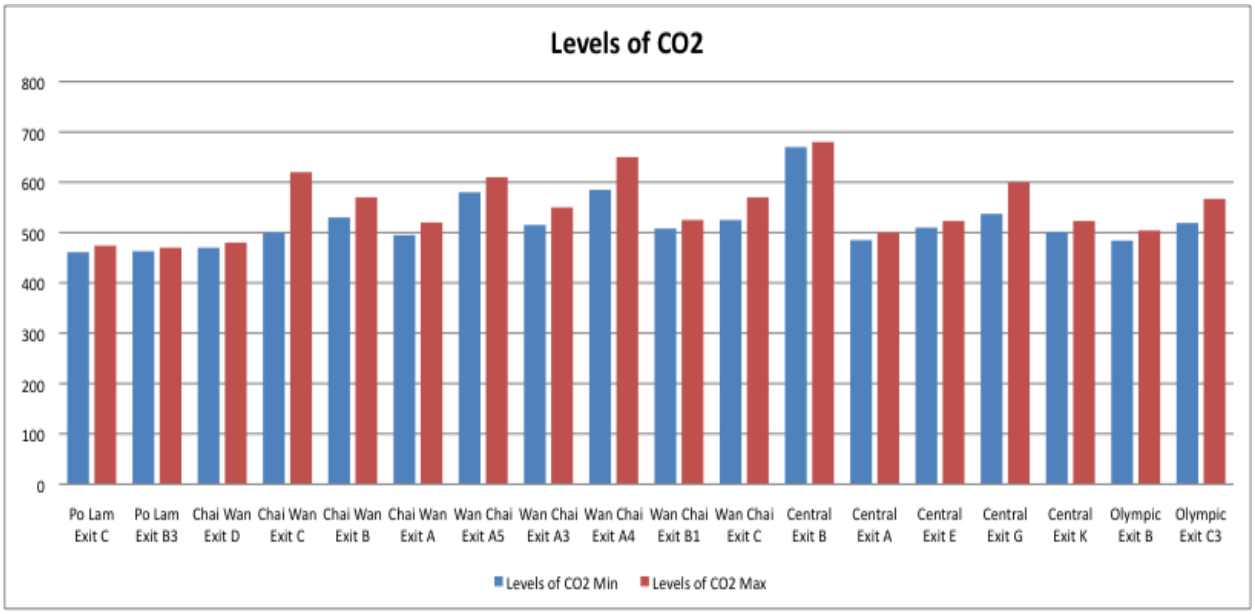
Picture E-17: Hospital

Picture E-15: Green areas between Hennessy Rd.

Picture E-18: Community Service Center

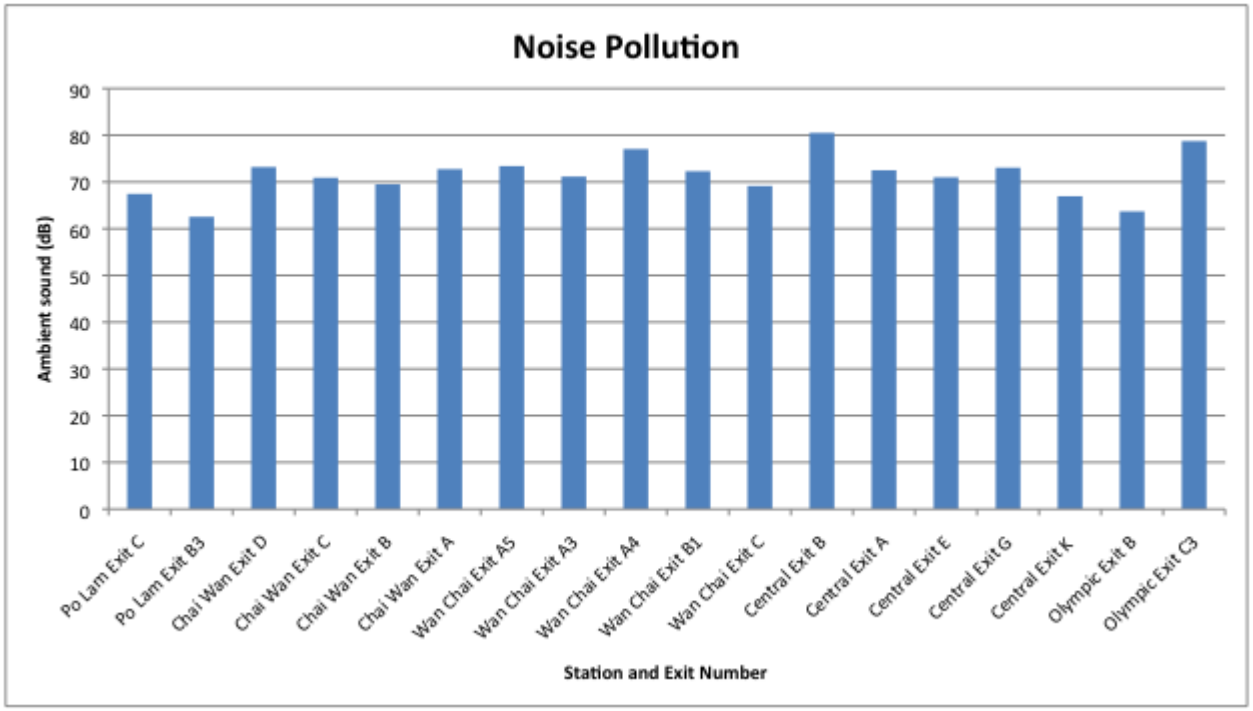
Appendix C: Overall Air Quality Measurements (Min, Max, Average)

Levels of CO2 (ppm)				
Station	**Location**	**Min**	**Max**	**Average**
Po Lam	Exit C	461	474	467.5
	Exit B3	463	470	466.5
Chai Wan	Exit D	470	480	475
	Exit C	500	620	560
	Exit B	530	570	550
	Exit A	495	520	507.5
Wan Chai	Exit A5	580	610	595
	Exit A3	515	550	532.5
	Exit A4	585	650	617.5
	Exit B1	508	525	516.5
	Exit C	525	570	547.5
Central	Exit B	670	680	675
	Exit A	485	500	492.5
	Exit E	510	523	516.5
	Exit G	537	600	568.5
	Exit K	501	523	512
Olympic	Exit B	484	504	494
	Exit C3	519	567	543



Appendix D: Overall Noise Pollution Measurements (Min, Max, Average)

Noise Levels in Decibels (dB)				
Station	**Location**	**Min**	**Max**	**Average**
Po Lam	Exit C	62.4	72.5	67.45
	Exit B3	58	67.1	62.55
Chai Wan	Exit D	69.4	77	73.2
	Exit C	68.3	73.5	70.9
	Exit B	66.4	72.6	69.5
	Exit A	69.2	76.3	72.75
Wan Chai	Exit A5	70	76.8	73.4
	Exit A3	66.3	76	71.15
	Exit A4	71.3	82.8	77.05
	Exit B1	66.9	77.7	72.3
	Exit C	64.7	73.6	69.15
Central	Exit B	76.2	84.8	80.5
	Exit A	69.2	75.8	72.5
	Exit E	65.3	76.7	71
	Exit G	70.1	76	73.05
	Exit K	64.7	69.2	66.95
Olympic	Exit B	60	67.4	63.7
	Exit C3	74.7	82.8	78.75



Appendix E: Survey

Evaluating The Sustainability of HKSAR's Transit-Oriented Developments

A Study conducted by Worcester Polytechnic Institute and The Hong Kong Institute of Education

Statement of Anonymity

We declare that no personal identifiable data will be disclosed to the public. No identifying information will be collected or disseminated. Your responses will be anonymous and serve as data for our study, outlined below. Your participation is not required, but greatly appreciated to improve the quality of new and existing developments in HKSAR.

Please direct any questions or concerns by email to transithk2012@wpi.edu

Sincerely,
Dwight Boatman
Brandon C. Bukowski
Mengxi Du
Kevin Ramirez

Introduction

The purpose of our study is to evaluate the sustainability of Transit-Oriented Developments in HKSAR. This survey has been constructed to collect the public's perceptions about their local ToD, and comment about sustainable development. We ask that you thoughtfully answer each question with regards to your closest MTR station, and then check off the corresponding box at the end of our survey. If you have further thoughts or would like a full copy of our paper upon completion, we can be reached at transithk2012@wpi.edu

1. How often do you use public transportation?
   - ☐ 7 days a week
   - ☐ 4 -6 days per week
   - ☐ 1-3 days per week
   - ☐ Less often

2. Do you find the area being accessibly noisy?

   1 ☐ 2 ☐ 3 ☐ 4 ☐

   Strongly Disagree Strongly Agree

3. Which of the following is your primary method for commuting to work?
   - ☐ Car
   - ☐ Train
   - ☐ Bus
   - ☐ Walk
   - ☐ Other _____

4. Approximately how long does it take to walk to the train station?
   - ☐ Less than 5min.
   - ☐ 5-10min.
   - ☐ 11-20min.
   - ☐ More than 20min.

5. Are the paths toward the station in good condition?
   1 ☐ 2 ☐ 3 ☐ 4 ☐
   Strongly Disagree Strongly Agree

6. Do you feel like the walkways are congested?
   1 ☐ 2 ☐ 3 ☐ 4 ☐
   Strongly Disagree Strongly Agree

7. I prefer living near the station
   ☐ YES
   ☐ NO
   Briefly explain why? (commuting time, street life, ease of access, local environment, etc.)
   _____
   _____

8. Do you feel like the station exits lead you to your destination?
   1 ☐ 2 ☐ 3 ☐ 4 ☐
   Strongly Disagree Strongly Agree

9. Are you able to get your supplies near the station? (Food, clothing, medicine, etc.)
   1 ☐ 2 ☐ 3 ☐ 4 ☐
   Strongly Disagree Strongly Agree

10. What key supplies do you think are missing from the area around the station?

_____
_____

11. Do you feel like the area promotes a healthy life style?
    1 ☐ 2 ☐ 3 ☐ 4 ☐
    Strongly Disagree Strongly Agree

12. What services does the area have that promote a healthy life style?

_____
_____

13. Do you feel like the area is aesthetically pleasing?

1 ☐ 2 ☐ 3 ☐ 4 ☐
Strongly Disagree Strongly Agree

14. Which of the following is your closest MTR station

Central
Olympic
Po Lam
Wan Chai
Chai Wan

Appendix F: Open Response Survey Questions

Survey Question 10

Central	Olympic	Chai Wan	Po Lam	Wan Chai
Coffee shop	Timetable of transportation	Library	Sports things	Food market
Restroom	Restroom	Restroom	Super market	Restroom
Wi-Fi	Tissue	Entertainment Place	diverse food	ATM
Relaxation facility	Park	Sprts Courts	"Stationer"	Super Market
Market	Cheap items	N/A	Restroom	N/A
Super Market	Super Market		N/A	
No chioce for shops (Only shop chains)	Restaurant			
Connection between station and buildings	Park allowing dogs			
N/A	Clinic			
	Library			
	Snack bar			
	Food market			
	Cheap residential building			

Survey Question 12

Central	Olympic	Chai Wan	Po Lam	Wan Chai
Trees	Cheery Street Park	Clinic	Park	Park
Green area	Bus station	Sports court	Sports court	Sports court
Rest place (park, etc.)	Park	Park	Trees	Football
Transportation	Food market	Gym	Cycling path/track	Gym
Health drinks	Sports court		Hospital	
Yoga	Library			
Less noise				
Light pollution				
Environmental education booth				